WORLD BANK GROUP

ECREEE

TOWARDS SUSTAINABLE ENERGY

REGIONAL OFF-GRID ELECTRIFICATION PROJECT

Off-Grid Solar Market Assessment & Private Sector Support Facility Design

GHANA REPORT

JULY 2019

GreenMax Capital Advisors

Energio Verda
Renewable Energy for Development

ASD

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ABBREVIATIONS & ACRONYMS

AFD	Agence Française de Développement (French Development Agency)
AfDB	African Development Bank
ASD	Africa Solar Designs
BOAD	Banque Ouest Africaine de Développement (West African Development Bank)
BoG	Bank of Ghana
C&I	Commercial and Industrial
CAPEX	Capital Expenditure
CAR	Capital Adequacy Ratio
CEESD	Centre for Energy, Environment, and Sustainable Development
CEADIR	Climate Economic Analysis for Development, Investment, and Resilience
CIF	Climate Investment Funds
COD	Cash-on-Delivery
CU	Credit Union
CUA	Credit Unions Association
DANIDA	Danish International Development Agency
DFI	Development Finance Institution
DfID	Department for International Development
DMB	Deposit Money Banks
EBID	ECOWAS Bank for Investment and Development
ECA	Export Credit Agency
ECCAS	Economic Community of Central African States
ECG	Electricity Company of Ghana Limited
ECOWAS	Economic Community of West African States
ECOWREX	ECOWAS Observatory for Renewable Energy and Energy Efficiency
ECREEE	ECOWAS Center for Renewable Energy and Energy Efficiency
EIB	European Investment Bank
ESMAP	Energy Sector Management Assistance Program
EU	European Union
EUEI	European Union Energy Initiative
EUR	Euro
EVA	Energio Verda Africa
FAO	Food and Agriculture Organization of the United Nations
FEI	Facility for Energy Inclusion
FGD	Focus Group Discussion
FH	Finance House
FI	Financial Institution
FNGOs	Financial Non-Governmental Organization
FX	Foreign Exchange
GCSCA	Ghana Cooperative Susu Collectors Association
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEDAP	Ghana Energy Development and Access Project
GHS	Ghanaian Cedi
GIIN	Global Impact Investing Network
GIS	Geographic Information Systems
GoG	Government of Ghana
GOGLA	Global Off-Grid Lighting Association
GPOBA	Global Partnership on Output-Based Aid

GRIDCo	Ghana Grid Company
GSGDA	Ghana Shared Growth and Development Agenda
GSMA	Groupe Spéciale Mobile Association (Global System for Mobile Communications)
HC	Health Center
HDI	Human Development Index
HFO	Heavy Fuel Oil
HH	Household
ICT	Information and Communications Technology
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IMF	International Monetary Fund
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
kW	Kilowatt
kWh	Kilowatt-hour
LTO	Lease-to-Own
MCC	Millennium Challenge Corporation
MFI	Microfinance Institution
MFC	Microfinance Company
MOE	Ministry of Energy
MTF	Multi-Tier Energy Access Framework
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Action
NGO	Non-Governmental Organization
NBFI	Non-Bank Financial Institution
NEDCo	Northern Electricity Distribution Company
NES	National Electrification Scheme
NGO	Non-Governmental Organization
NPL	Non-Performing Loan
NREAP	National Renewable Energy Action Plan
NRES	National Renewable Energy Strategy
O&M	Operation and Maintenance
OGE	Off-Grid Electric
OGS	Off-Grid Solar
PAYG	Pay-As-You-Go
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PUE	Productive Use of Energy
PURC	Public Utility Regulatory Commission
PV	Photovoltaic
RCB	Rural and Community Bank
RDF	Rural Development Fund
RE	Renewable Energy
REA	Renewable Energy Authority
REMP	Renewable Energy Master Plan
REF	Renewable Energy Fund
RISE	Regulatory Indicators for Sustainable Energy

ROA	Return on Assets
ROE	Return on Equity
ROGEP	Regional Off-Grid Electrification Project
S&L	Savings and Loan Companies
SDI	Specialized Deposit-taking Financial Institution
SEFA	Sustainable Energy Fund for Africa
SEforALL	Sustainable Energy for All
SHEP	Self-Help Electrification Programme
SHS	Solar Home System
SLAP	Solar Lantern Promotion Programme
SME	Small and Medium Enterprise
SNEP	Strategic National Energy Plan
SUNREF	Sustainable Use of Natural Resources and Energy Finance
SPSD	Support to Private Sector Development Programme
SPV	Special Purpose Vehicle
SREP-IP	Scaling-up Renewable Energy Investment Plan
SSA	Sub-Saharan Africa
TA	Technical Assistance
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USADF	United States African Development Foundation
USD	United States Dollar
VAT	Value Added Tax
VRA	Volta River Authority
VSLA	Village Savings and Loan Association
WAPP	West African Power Pool
WB	World Bank
Wh	Watt-hour
WHO	World Health Organization
Wp	Watt peak

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NOTE: The findings, analysis, conclusions and recommendations expressed in this report are those of the authors – they do not necessarily represent the views of ECREEE, the World Bank, or any of the individuals and organizations that contributed to this study.

KEY DEFINITIONS

ELECTRICITY ACCESS

For the purpose of this analysis, figures on national, urban and rural electrification rates are from the International Energy Agency (IEA) Energy Access Outlook Report, 2017.[1] Although local government authorities (energy ministries, rural electrification agencies, utilities etc.) may have different or more up-to-date electrification data, one single, uniformly-accepted source was necessary as a baseline to assess electricity access figures across all 19 of the countries analyzed under this regional market assessment.

There is no single internationally-accepted and internationally-adopted definition of modern energy access. The IEA defines energy access as "a household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time to reach the regional average."[2] A "basic bundle of energy services" means, at a minimum, several lightbulbs, task lighting (such as a flashlight or lantern), phone charging and a radio. This definition of energy access serves as a benchmark to measure progress towards UN Sustainable Development Goal 7.[3] The IEA electricity access statistics presented in this report include household connections, either from a grid connection or from a renewable energy-based off-grid source; the approach excludes illegal connections. The data is sourced wherever possible from governments, supplemented by data from multilateral development banks, various international organizations and other publicly available statistics.

The Multi-Tier Energy Access Framework (MTF) is also used as a key reference throughout this report. Rather than measuring electricity access as a household connection to an electricity grid, the MTF views electricity access along a continuum of service levels (tiers) and according to a series of indicators, including capacity, availability/duration of supply, reliability, quality, affordability, legality and health/safety.[4]

OFF-GRID / STAND-ALONE SOLAR

The term "off-grid" as it is widely used throughout this report (e.g. "off-grid sector") refers to both mini-grids and stand-alone systems. When "off-grid solar" or its acronym "OGS" are used, this refers *only* to stand-alone solar systems and does not include mini-grids. The main focus of this market assessment is the stand-alone solar sector. While micro/mini-grids typically provide a small community with electricity, stand-alone solar systems are not connected to an electricity distribution system and typically include a battery, but may also be used in conjunction with a diesel generator, wind turbine etc. Stand-alone solar technology broadly includes the following:

- Pico solar/solar lanterns[5]
- Single module solar systems (DC)[6]
- Multiple module solar systems (AC)[7]
- Large solar systems (AC)[8]

In addition to providing electricity access, stand-alone solar products/systems also support a wide range of productive applications (e.g. solar water pumping, agricultural processing, milling equipment, refrigeration etc.).

[1] https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[2] https://www.iea.org/energyaccess/methodology/
[3] https://sustainabledevelopment.un.org/sdg7
[4] "Multi-Tier Framework for Measuring Energy Access," World Bank ESMAP: https://www.esmap.org/node/55526
[5] Typically less than 10 Wp; all-in-one lighting and/or phone charging; enables partial or full Tier 1 electricity access
[6] Typically 11-100 Wp; capable of powering a few appliances (lights, mobile phone charging, TV, radio, fan etc.); often referred to as a "plug-and-play" solar home system when components are sold as a set; enables full Tier 1 or higher electricity access
[7] Typically 101-500 Wp; capable of powering multiple appliances; requires small inverter
[8] Typically greater than 500 Wp; most often used to power a large home; requires large inverter

Multi-tier Matrix for Measuring Access to Household Electricity Supply

ATTRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
				Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhr/ day	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
	4. Quality						Voltage problems do not affect the use of desired appliances	
	5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
	6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
	7. Health & Safety						Absence of past accidents and perception of high risk in the future	

Source: World Bank Energy Sector Management Assistance Program (ESMAP)

WEST AFRICA AND THE SAHEL

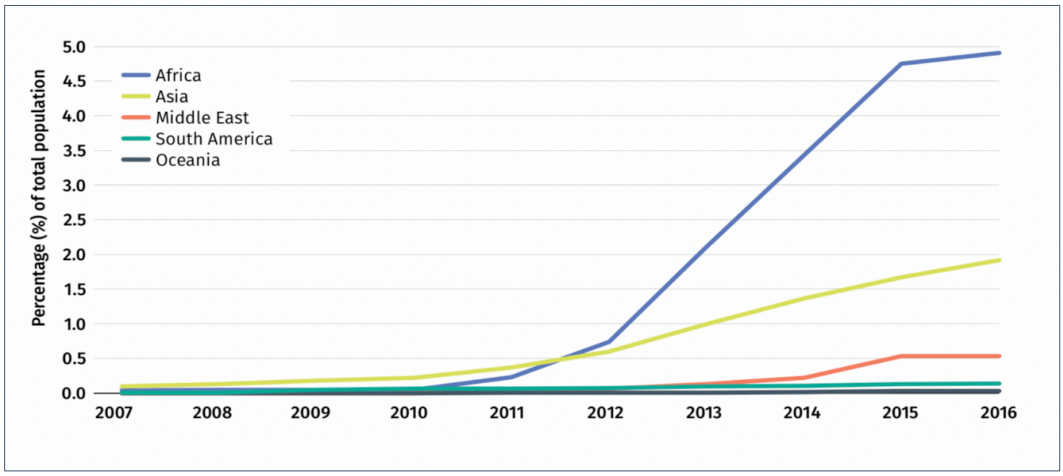
The term "West Africa and the Sahel" as it is used to throughout this report refers to the 19 countries covered by the first phase of the Regional Off-Grid Electrification Project (ROGEP). The countries include the 15 member states of the Economic Community of West African States (ECOWAS) – Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal and Togo – plus Cameroon, Central African Republic, Chad and Mauritania.

EXECUTIVE SUMMARY

I. INTRODUCTION

Access to electricity in Sub-Saharan Africa has improved significantly over the past decade. The number of people without access to electricity in the region stopped increasing for the first time in 2013 and has since declined.[9] Although grid connections continue to be the primary method of electrification, access to electricity through off-grid renewable energy systems has grown considerably. The use of off-grid solar (OGS) power is notably on the rise, with African countries accounting for most of the sector's growth over the last decade (**Figure ES-1**). The pace of solar electrification has accelerated more rapidly in Sub-Saharan Africa than anywhere in the world.[10] In order to achieve universal electrification by 2030, the International Energy Agency (IEA) estimates that Sub-Saharan Africa will need more than half of new electricity access connections between 2017 and 2030 to be made through decentralized systems (mini-grids and stand-alone systems), with solar technologies representing nearly 60% of these connections.[11]

Figure ES-1: Off-Grid Solar Access Rate by Region



Tier 1 access and above

Source: International Renewable Energy Agency

Despite this progress, government efforts to increase electricity access in Africa have struggled to keep pace with rapid population growth and increasing demand. Many countries across the region must navigate the interrelated challenges of energy poverty, energy security and climate change (among other sociopolitical, economic and development challenges), which collectively slow the adoption of renewable energy and the pace of off-grid market growth. Rates of energy access remain particularly low in rural areas, where the electrification rate is less than 25% across Sub-Saharan Africa.[12] In part, this is due to the gap between the power sector's infrastructure needs and the availability of necessary resources to expand grid electrification. Extending the grid to rural areas can be challenging due to significant transmission distances and low population densities.

[9] "Energy Access Outlook, 2017: From Poverty to Prosperity," International Energy Agency, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[10] "Tracking SDG7 – The Energy Access Report 2018," The World Bank, IEA, IRENA, UN Statistics Division and the WHO, (2018): https://openknowledge.worldbank.org/handle/10986/29812
[11] Tracking SDG7 – The Energy Access Report, 2018.
[12] IEA Energy Access Outlook, 2017.

As of 2016, over 200 million people in West Africa and the Sahel – more than half of the region's population – lacked access to electricity. This figure represents nearly one-third of Africa's total unelectrified population. Rates of urban and rural electrification vary widely across the region, with the average rate of access nearly three times higher in urban areas.[13]

Despite these access deficits, the region is generously endowed with renewable energy resources – including hydropower, solar, wind and bioenergy. These resources are largely untapped, however, as investments in the power sector remain high-risk due to market instability, as well as a variety of political and regulatory risks. Other energy sector challenges include *inter alia* limited institutional capacity, poor utility financial performance, a shortage of local technical expertise and a lack of support from local financial institutions (FIs).

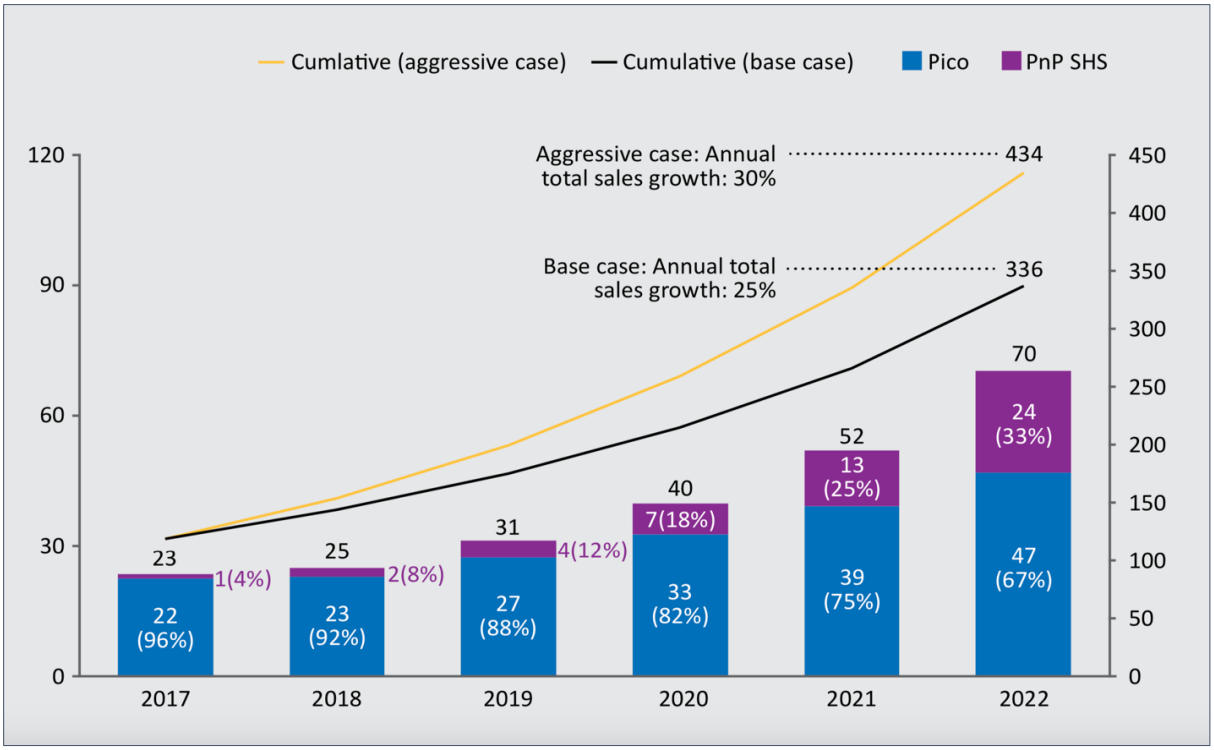
Until recently, diesel generators largely served as the expensive alternative both for rural electrification and for urban and peri-urban "bad grid" areas, where electricity was unreliable or only available for part of the day. However, the advent of decentralized renewable energy technologies, particularly stand-alone solar and mini-grid systems, offers opportunities to deliver clean and cost-effective off-grid solutions. Accordingly, policymakers are increasingly utilizing these options in electrification planning as they offer a reliable, flexible and relatively affordable complement to grid extension initiatives.

Solar energy is the most promising technology in the off-grid space, with three key trends converging to drive the industry's growth: first, continued reductions in hardware and balance of system costs (solar modules, batteries, inverters, appliances etc.); second, a digital revolution, with mobile communication technology facilitating payments and monitoring; and third, innovation in private sector business models, such as pay-as-you go (PAYG) and third-party ownership of solar home systems (SHS), which offer energy as a service and remove previously prohibitive up-front costs for households.[14] As a result of these developments, the off-grid solar market is rapidly evolving and expanding.

In 2016, the OGS market reported global revenues of approximately USD 1 billion. This figure is expected to increase to USD 8 billion by 2022, with SHS representing the majority of this revenue growth and an increasing share of unit sales **(Figure ES-2)**. Investments in the off-grid solar sector doubled annually between 2012 and 2016, increasing by 98% over this period. Between 2013 and 2017, East Africa represented 86% of the global PAYG market in terms of cumulative unit sales, followed by West Africa at 12% and Asia at 2%.[15] As the East African market becomes more crowded and solar companies expand their operations into West Africa, the region will account for a larger geographic share of the burgeoning global OGS market. Although the sector's investment trends remain volatile, there is some preliminary evidence to suggest that this transition is already underway: in 2016, West Africa accounted for 34% of total funds raised, up from 9% in 2015, while East Africa's share of funding decreased from 77% to 47% over the same period.[16]

[13] IEA Energy Access Outlook, 2017.
[14] "Derisking Renewable Energy Investment: Off-Grid Electrification," United Nations Development Programme (UNDP) and ETH Zurich, (December 2018): https://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Climate%20Strategies/DREI%20Off-Grid%20Electrification%20-%20Full%20Report%20(20181210).pdf
[15] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf
[16] Ibid.

Figure ES-2: Global Off-Grid Solar Market Forecast (million units sold)



NOTE: Left axis = annual sales volume; Right axis = cumulative sales volume; PnP SHS = Plug-and-Play Solar Home System

Source: Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP

Many international off-grid solar companies, including most of the industry's leading players – BBOXX, Greenlight Planet, Azuri, d.light, Off-Grid Electric, M-KOPA Solar, Fenix International, and French utilities EDF and Engie among others – have recently entered markets in West Africa, joining international pioneers such as PEG and Lumos, which launched originally in Ghana and Nigeria, respectively, and both expanded into Côte d'Ivoire and Togo.[17] While these large international companies are well capitalized, there is a dearth of financing for smaller, early-stage companies that operate in nascent markets across West Africa and the Sahel. In fact, the top 10 global off-grid solar companies have received nearly 90% of investment capital since 2012, while early-stage companies often struggle to raise the necessary capital to accelerate growth.[18]

In order to scale off-grid electrification, OGS companies will need to access large volumes of commercial debt financing. In the longer term, partnerships with local commercial banks and microfinance institutions (MFIs) will also be necessary in order to develop domestic, local-currency sources of financing and reduce foreign exchange risk.[19] Partnerships with local FIs, whose understanding of the credit risk of local populations, may also reduce financing costs more rapidly compared to other methods (e.g. using debt from securitized receivables).[20] Although most financing currently comes from non-commercial sources (i.e. the

[17] Bavier, J., "Off-grid power pioneers pour into West Africa," Reuters, (February 20, 2018): https://www.reuters.com/article/us-africa-power-insight/off-grid-power-pioneers-pour-into-west-africa-idUSKCN1G41PE
[18] "Accelerating Energy Access: The Role of Patient Capital," Acumen, (2018): https://acumen.org/wp-content/uploads/Accelerating-Access-Role-of-Patient-Capital-Report.pdf
[19] UNDP and ETH Zurich, 2018.
[20] "How can Pay-As-You-Go Solar Be Financed?" Bloomberg New Energy Finance, (7 October 2016): https://www.bbhub.io/bnef/sites/4/2016/10/BNEF_WP_2016_10_07-Pay-as-you-go-solar.pdf

international development community), global capital markets have the size and depth necessary to meet this investment challenge. Nevertheless, small investment sizes and other early-stage market investment risks are currently holding back abundant and low-cost private capital flows to the off-grid sector.[21]

In order to mitigate risks and spur investment, the OGS sector requires substantial policy and regulatory support. It is therefore important that governments send a clear signal to the private sector by integrating off-grid technologies into national development programs, electrification plans and electricity access targets. Governments should also adopt favorable policies, laws and regulations to boost private sector participation, including procurement and tax incentives, grants and subsidies, concession schemes, streamlined licensing and permitting procedures, and quality standards for equipment. Additional measures include public awareness raising, encouraging inclusive gender participation, and building local capacity at all levels (e.g. solar PV vocational training and technical certification programs, training for FIs to address unfamiliarity of lenders with off-grid solar sector, corporate and consumer financing needs etc.).

In addition, solar companies increasingly rely on mobile money platforms to scale their business, as mobile payments allow them to offer low-income customers new ways to access and pay for electricity through innovative business models such as PAYG. Mobile money services, however, are only just beginning to be deployed in West Africa and the Sahel. Solar companies are therefore limited by low levels of penetration and in some cases by country-specific regulatory restrictions.[22] Governments can take action to foster linkages between the off-grid solar, telecommunications and mobile money sectors to expedite the uptake of market-transforming technology platforms and business models.

Governments across West Africa and the Sahel have implemented a range of policies and approaches to support off-grid market development, including private concessions, Public Private Partnerships (PPPs), Rural Electrification Agencies (REAs) and Rural Electrification Funds (REFs), among other measures. Some countries like Senegal and Mali have adopted private concessions to scale up mini-grids in rural areas, while others, such as Nigeria and Ghana, have improved rural electrification largely through public investment.

To support these initiatives, the Economic Community of West African States (ECOWAS) adopted the ECOWAS Renewable Energy Policy (EREP) in 2013, which intends to achieve universal electricity access in the region by 2030. The EREP also aims to increase the share of the region's rural population served by decentralized renewable energy services (mini-grids and stand-alone systems) to 25% by 2030. The ECOWAS Center for Renewable Energy and Energy Efficiency (ECREEE) is working with member states to develop and implement national policies and strategies with electrification targets through 2030 in line with the EREP, including Sustainable Energy for All (SEforALL) Action Agendas and National Renewable Energy Action Plans (NREAP), among other programs in support of renewable energy and off-grid market development.[23]

[21] UNDP and ETH Zurich, 2018.
[22] "Scaling Access to Energy in Africa: 20 Million Off-Grid Connections by 2030," Scaling Off-Grid Energy: A Grand Challenge for Development, USAID, UK DFID, Shell Foundation, (2018): https://static.globalinnovationexchange.org/s3fs-public/asset/document/SOGE%20YIR_FINAL.pdf?uwUDTyB3ghxOrV2gqvsO_r0L5OhWPZZb
[23] ECOWAS Renewable Energy Policy, 2013: http://www.ecreee.org/sites/default/files/documents/ecowas_renewable_energy_policy.pdf

II. BACKGROUND AND CONTEXT OF THE ASSIGNMENT

In this context, with funding from the World Bank, ECREEE launched the Regional Off-Grid Electrification Project (ROGEP) in 19 countries in West Africa and the Sahel. The project aims to enhance shared capacity, institutions and knowledge in order to increase electricity access of households, businesses and public institutions using modern stand-alone solar systems through a harmonized regional approach. ROGEP has two main components/objectives:

- ✓ **Component 1: Accelerate development of a regional off-grid solar market:**

  (1A) Foster regional collaboration and promote a supportive enabling environment for the OGS sector;
  (1B) Provide entrepreneurship technical support to OGS companies at various stages of development (training to accelerate business growth and/or facilitate market entry);
  (1C) Provide entrepreneurship financial support to OGS companies at various stages of development (matching grants);
  (1D) Provide financing to remove barriers in challenging markets (market entry grants and performance grants to OGS companies operating in challenging markets)

- ✓ **Component 2: Facilitate access to financing for off-grid solar businesses:**

  (2A) Provide line of credit for OGS businesses via the West African Development Bank (Banque Ouest Africaine de Développement, BOAD) to be extended to local FIs for on-lending to local entrepreneurs (working capital for companies to finance equipment imports, receivables from PAYG schemes etc.)
  (**2B**) Implement contingent grant facility via BOAD to share risks with local FIs and encourage lending to OGS businesses.

In addition, the project intends to support a range of capacity building activities targeting public and private sector stakeholders to address existing policy, regulatory, institutional, financial, economic, business, technology and capacity related barriers. ECREEE will also assist each country with development and implementation of national programs and initiatives in the areas of renewable energy, rural electrification and energy access in line with the regional focus of the assignment.

Under the first phase of the project, an initial assessment of the off-grid solar market was undertaken in each of the 19 countries. The study focused exclusively on the stand-alone solar PV market and did not assess mini-grids (see **Key Definitions**). The scope of work was broadly divided into the following tasks:

(1) Review the current enabling policy and market environment for the off-grid solar sector
(2) Analyze the market for off-grid solar products and systems, including an estimate of demand from the household, institutional and productive use market segments and analysis of the supply chain;
(3) Assess the willingness and capacity of national and regional financial institutions to provide commercial and/or consumer financing to the off-grid solar sector; and
(4) Propose models to incentivize the private sector and financial institutions to support off-grid solar market development and to harmonize a regional market to achieve universal access.

Available geographic information system (GIS) data for each country supported the Task 1 and Task 2 analyses. A least-cost electrification analysis was undertaken utilizing geospatial mapping to assess the potential development of electricity access and grid coverage in each country through 2023 and 2030. The study estimated the total number of potential settlements, people and households electrified by on-grid, mini-grid or off-grid stand-alone solutions under each timeframe based on a series of indicators, including national electricity grid proximity, population density and nodes of economic growth. The assessment was also performed for health facilities and education centers (although the analysis was limited by the

availability and/or quality of GIS data for these market segments). The results of the analysis were used to estimate the share of the population suitable for off-grid stand-alone solar solutions over the analyzed periods and to assess corresponding potential demand from the household sector under the Task 2 market sizing.

Within the context of this assignment, a gender-focused analysis was also implemented in order to assess the level of female participation in each country's off-grid energy sector. Each stage of the market study therefore analyzed inclusive participation and gender implications. A comprehensive gender profile is presented in **Annex 4**, including a summary of findings, as well as recommendations to improve gender equality and enhance women's engagement in development of the off-grid sector.

To carry out these tasks, the project team utilized a combination of desk research, input from local country experts and feedback from engagement with a wide range of stakeholders at the country and regional levels. Interviews were conducted with policymakers, industry experts, and representatives from solar companies and financial institutions. Focus group discussions were also held in each country with key stakeholders from the four market segments analyzed under Task 2 (household, institutional, productive use and supplier). Focus group participants included representatives from government, the donor community, NGOs, solar companies, business and industry associations, academia, community groups, and women's groups. In addition to the focus group meetings, surveys were administered in order to collect additional Task 2 market data, including (i) a survey of international solar companies to gauge their level of interest in the region; (ii) a survey of local solar companies and retail suppliers in each country to inform the supply chain analysis; and (iii) an assessment of an off-grid village in each country to better understand how solar is being utilized for productive uses. Under Task 3, a survey was administered to local and regional FIs to determine their level of capacity and interest in lending to the off-grid solar sector. A detailed description of the methodology used to carry out these tasks is presented in **Annexes 1-3**.

This report is organized into three sections that correspond to Tasks 1-3 described in the scope of work above (Task 4 was prepared in a separate report). **Section 1** covers the enabling policy and market environment for the OGS sector. This includes an overview of the status of the on-grid and off-grid markets, an analysis of off-grid energy policy and regulation and gaps in the existing framework, and a summary of off-grid development initiatives. The results of the least-cost electrification analysis are also included in this section.

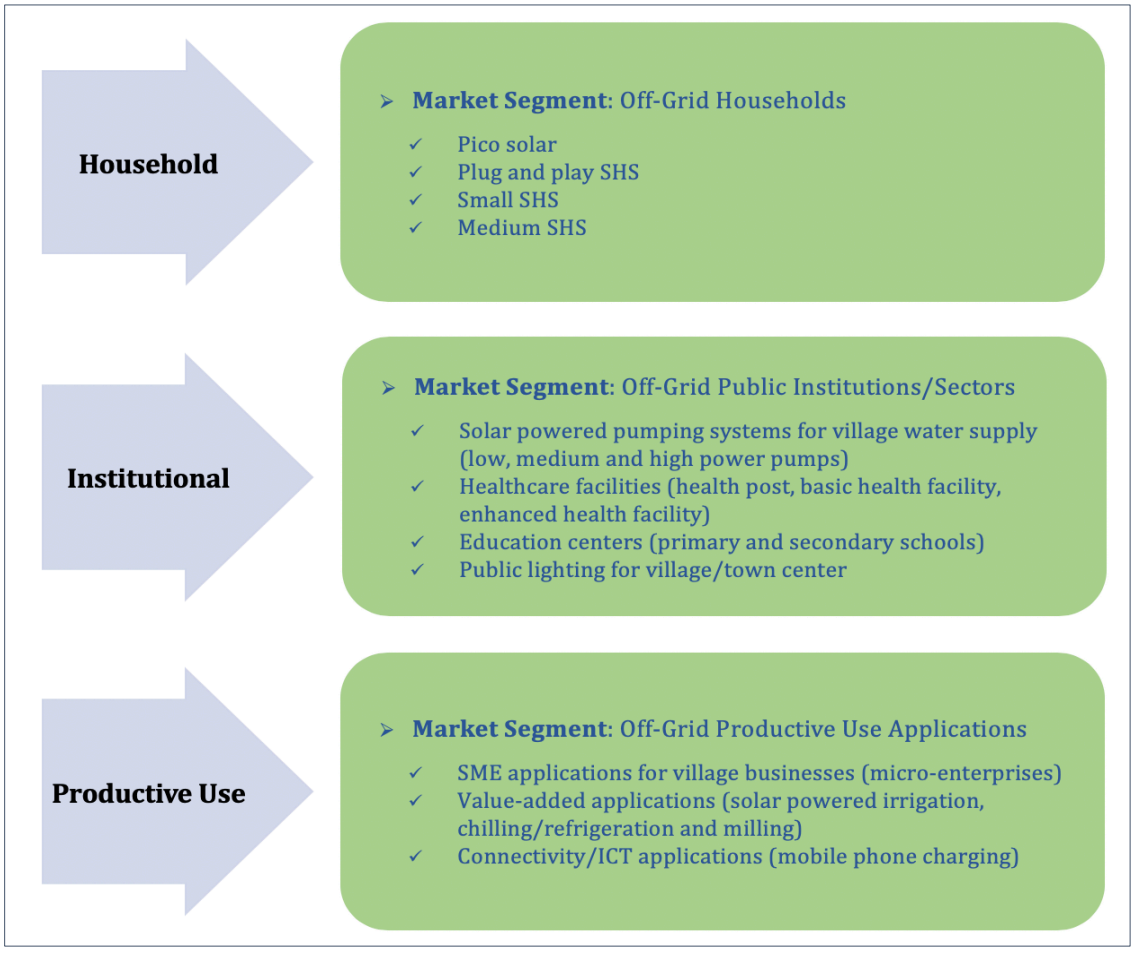
Section 2 estimates the potential market for off-grid solar products and systems by assessing potential demand from the household, institutional and productive use market segments (**Figure ES-3**), followed by an analysis of the supply chain. The household market sizing utilizes results from the least-cost electrification analysis, along with data on household income and energy expenditure, in order to estimate potential demand based on the number of households able to afford various OGS systems. Both the cash and financed market potential were estimated for 2018, 2023 and 2030.

The institutional sector analysis combines available GIS data with secondary research to estimate potential demand based on assumptions about the electricity needs, usage patterns and associated costs of solar electrification of four public/institutional markets – water supply for off-grid communities, healthcare facilities, education centers (primary and secondary schools) and public lighting. Where GIS data was unavailable, per capita comparisons were made using data from similar countries to estimate off-grid solar demand by market segment (see **Annex 2** for country categorization). The productive use of energy (PUE) market sizing estimates potential off-grid solar demand for SME, value-added and connectivity applications. Feedback from stakeholder interviews and focus group discussions informed the analysis and helped characterize each market segment's consumer perceptions, interest, awareness, ability to pay and access to finance.

The Task 2 supply chain analysis presents an overview of key market actors, solar products and services, sales figures and business models, and includes a discussion of the role of informal market players and the impact of uncertified products. The analysis also addresses the capacity needs of the supply chain and describes specific areas of support where technical assistance is needed to accelerate market growth.

Section 3 assesses the willingness and capability of national and regional financial institutions (FIs) to provide commercial and/or consumer financing to the off-grid solar sector in each country. This section includes a summary of financial products for the off-grid sector, a comprehensive overview of each country's financial market and commercial lending environment (including analysis of commercial banks, microfinance institutions and other non-bank financial institutions) and any programs supporting off-grid solar lending. This section also examines the scope of financial inclusion in each country and the impact of digital financial services and mobile money on access to finance. It concludes with the results of surveys that were administered to financial institutions in each country across the region.

Figure ES-3: Analyzed Off-Grid Market Segments



NOTE: SHS = Solar Home System; ICT = Information Communication Technology

III. EXECUTIVE SUMMARY

Ghana is a lower middle-income country with a strong market-based economy with few barriers to trade and investment compared to other countries in the region. Economic growth remains promising and is expected to continue in the near-term, supported by an increase in crude oil production. Poverty has steadily declined in Ghana but still afflicts more than one-third of the country's rural inhabitants. While the country has transitioned to a services-oriented economy, about half of the labor force remains in the agricultural sector.

Ghana has one of West Africa's highest rates of electricity access. In 2016, approximately 16% of the population – an estimated 4 million people – lacked access to electricity, with a disparity between rates of access in urban (95%) and rural (71%) areas.[24] Some communities remain without access to electricity either because they are inaccessible or there is not a viable economic model for extending the distribution network. Where grid connections exist, power supply is often unreliable; fewer than one fifth of firms and about half of households reported having reliable access to electricity when surveyed.[25] The Government of Ghana (GoG) has implemented a robust framework to address these challenges.

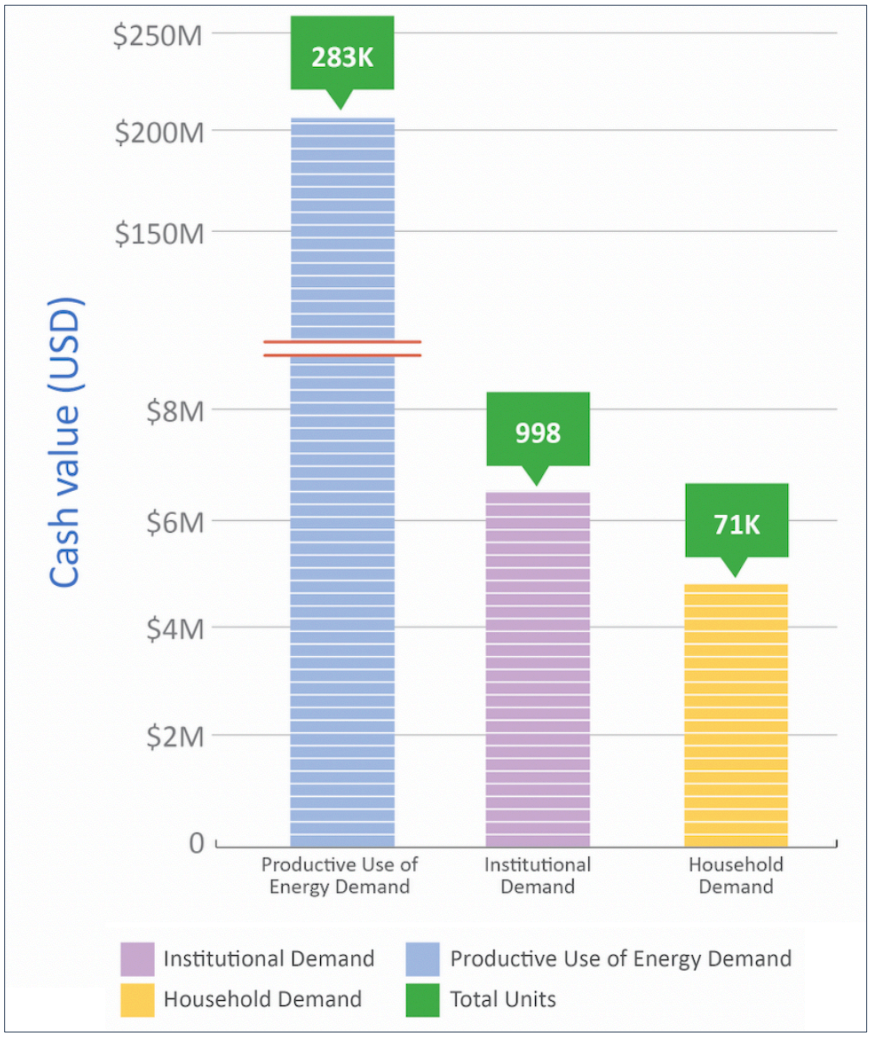
Ghana's Energy Sector Strategy and Development Plan, as well as the Renewable Energy Master Plan aim to achieve universal access to electricity by 2030. To date, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector are progressing well, as evidenced by the country's improvement in its World Bank Regulatory Indicators for Sustainable Energy (RISE) energy access score between 2015 and 2017. In the 2017 RISE evaluation, Ghana ranked second behind only Cameroon in West Africa and the Sahel and was among the highest scoring countries in Africa.[26]

Ghana began addressing electrification in 1989 when the GoG initiated the National Electrification Scheme (NES) as its principal policy to extend electricity supply to all parts of the country over a 30-year period from 1990 to 2020. In 2007, to supplement the NES, the Government instituted the Self-Help Electrification Programme (SHEP) to assist communities in advancing their connection to the national electricity grid. In 2015, with support from ECREEE, the Government outlined its commitments and initiatives to develop renewable energy and meet its electrification targets in its SEforALL National Renewable Energy Action Plan (NREAP). Subsequently, in 2019, with funding from UNDP and DANIDA, Ghana published a Renewable Energy Master Plan (REMP), which includes a series of targets in five-year blocks through 2030. The REMP intends to add a total of 20 MW of stand-alone solar by 2030 and also aims to support integration of existing stand-alone systems into mini-grids under the country's existing net metering scheme.[27]

This report assesses the market opportunity for off-grid solar products and systems by estimating demand from the household, institutional, and productive use sectors in Ghana (**Figure ES-4**). According to the assessment, there is a significant OGS market opportunity, with the annualized cash market potential in 2018 estimated to be USD 217.1 million. The productive use sector (USD 205.8M) makes up the majority of estimated demand, followed by the institutional (USD 6.5M) and household (USD 4.8M) sectors.

[24] IEA Energy Access Outlook, 2017.
[25] Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y
[26] "Policy Matters: Regulatory Indicators for Sustainable Energy," World Bank ESMAP, (2018): http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf
[27] Ghana Renewable Energy Master Plan: https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/UNDP_GH_SUS_DEV_REN_MASTER_PLAN_2019.pdf

Figure ES-4: Indicative Total Cash Market Potential for Off-Grid Solar Products in Ghana, 2018

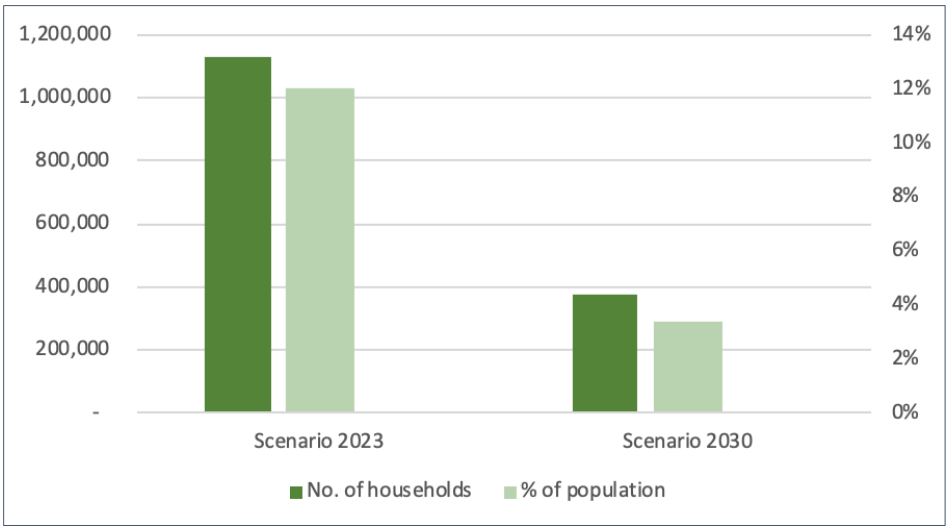


Source: African Solar Designs analysis

The least-cost electrification analysis found that by 2023, 8,373 settlements across Ghana (5,948,889 households) will be connected to the main grid, representing 63.6% of the population. By 2030, this figure will increase to 18,384 settlements (9,663,851 households), equivalent to 88.7% of the population. These estimates are based on the assumption that all planned grid extensions will be completed by 2030.

The remaining more dispersed settlements (further from centers of economic activity) can optimally be served by off-grid stand-alone systems (**Figure ES-5**). This comprises 4,874 settlements (1,127,303 households) and 12.0% of the population in 2023, decreasing to 1,597 settlements (372,913 households) and 3.4% of the population in 2030. While the total size of the OGS market will decrease over time, it will also become more concentrated in remote regions, particularly in Northern and Brong Ahafo, where the highest number and concentration of off-grid households will be located. Markets in Great Accra, Western and Ashanti will shrink significantly. This has implications for solar product market long-term business models, which will need to consider broader distribution areas as the total number of off-grid households declines.

Figure ES-5: Estimated Number of Households and Share of Population Suitable for OGS Systems in Ghana, 2023 and 2030

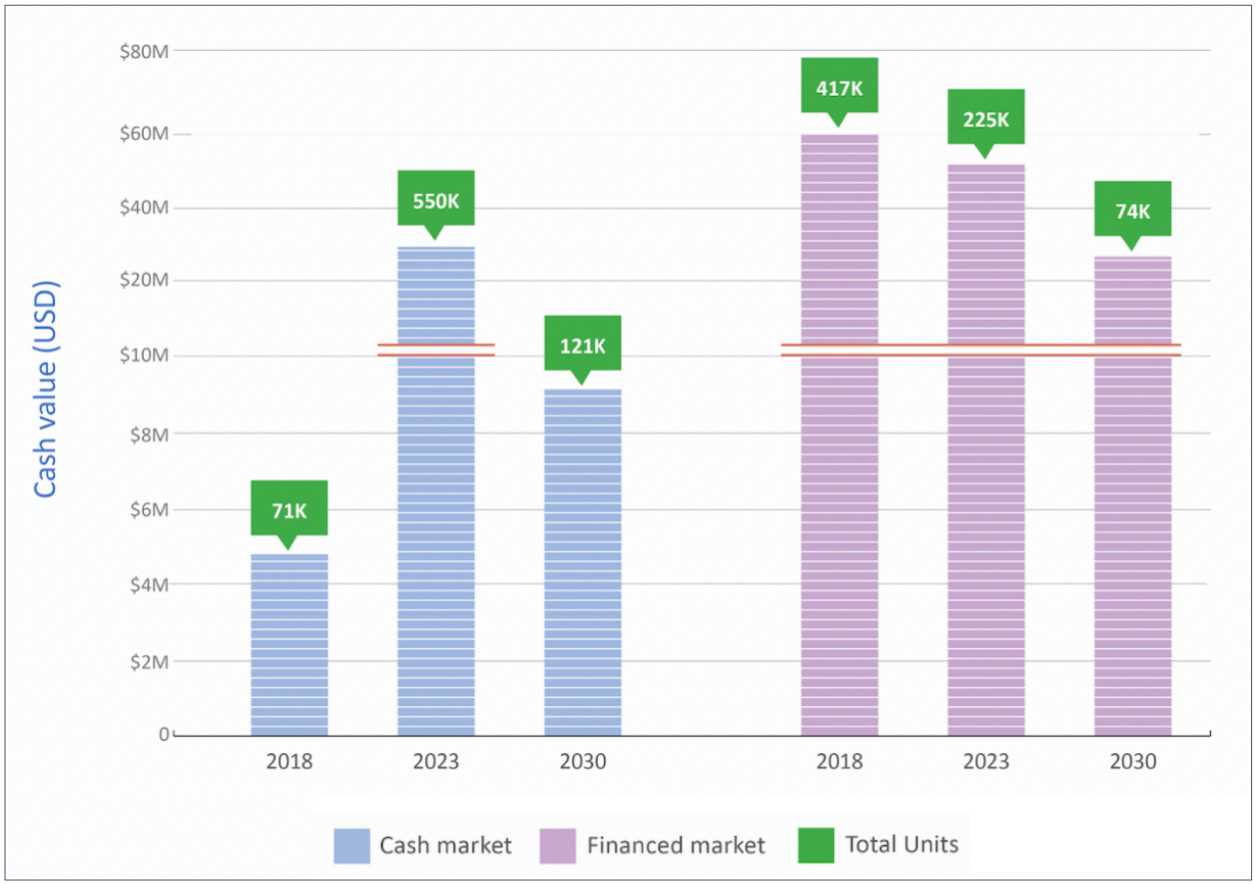


Source: Energio Verda Africa GIS analysis

According to the analysis, the annualized off-grid solar cash market potential for the household sector in 2018 is USD 4.8 million, with the estimated market value increasing more than *tenfold* in size to USD 60 million with the addition of consumer financing (**Figure ES-6**). Consumer financing allows the poorest households to enter the market and those already in the market to afford larger systems.

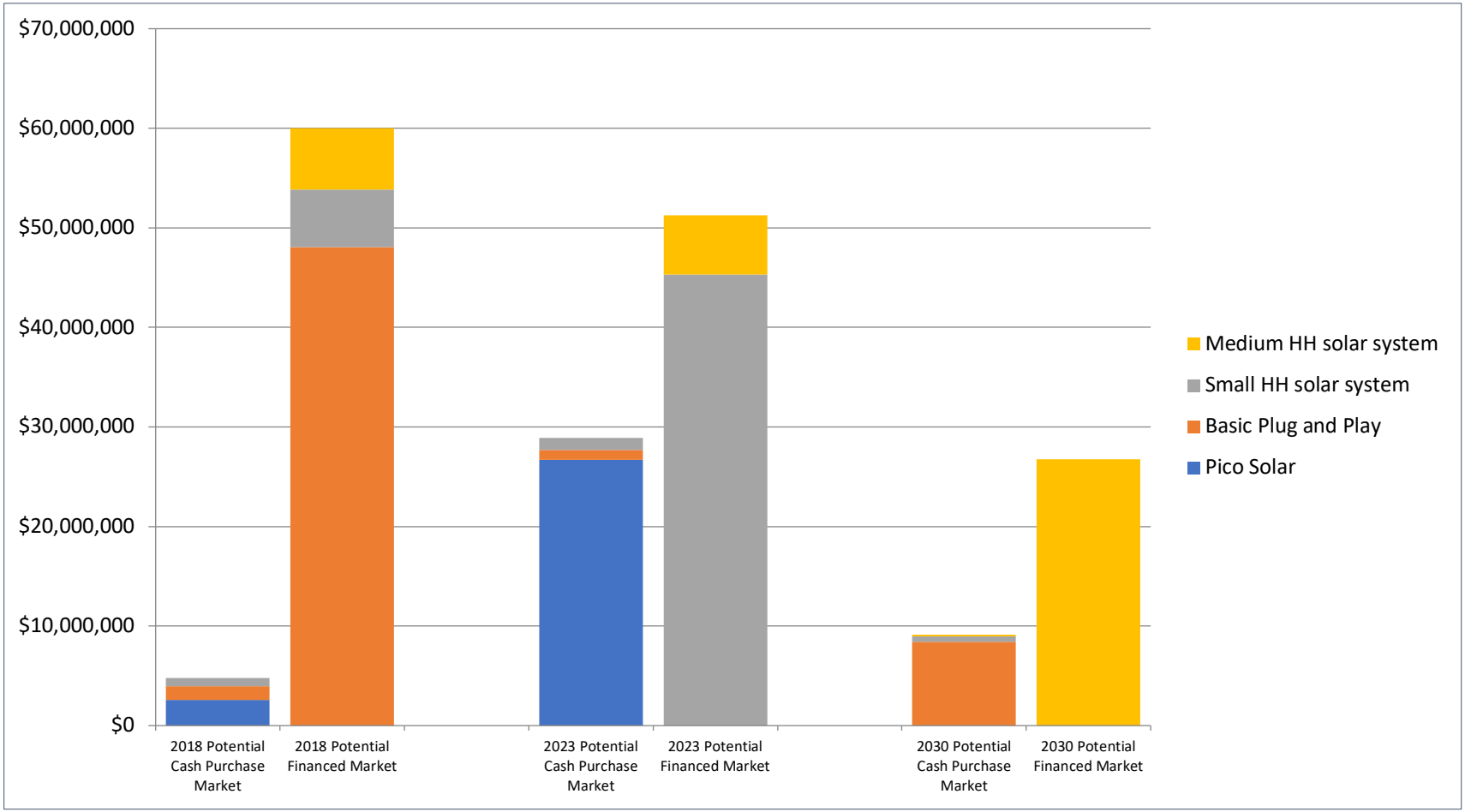
According to the assessment, the most common types of systems the market can afford on a cash basis are pico solar and small plug and play systems; however, this changes significantly with the introduction of financing (**Figure ES-7**). While affordability improves over time, households in the lowest income quintiles cannot afford any off-grid solar products without financing. Consumer financing will therefore prove critical for accelerating off-grid solar market growth and meeting electrification targets through 2030.

Figure ES-6: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector



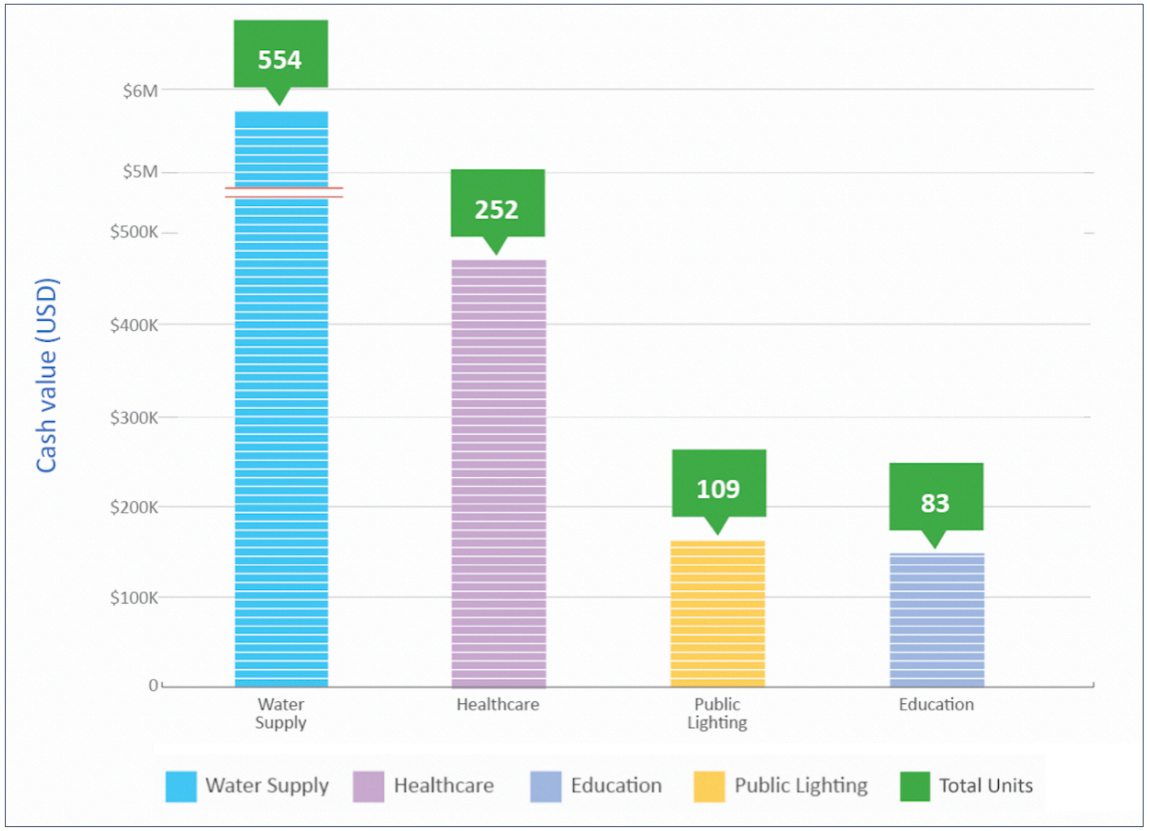
Source: African Solar Designs analysis

Figure ES-7: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector by System Type



Source: African Solar Designs analysis

Figure ES-8: Estimated Off-Grid Solar Cash Market Potential for Institutional Sector

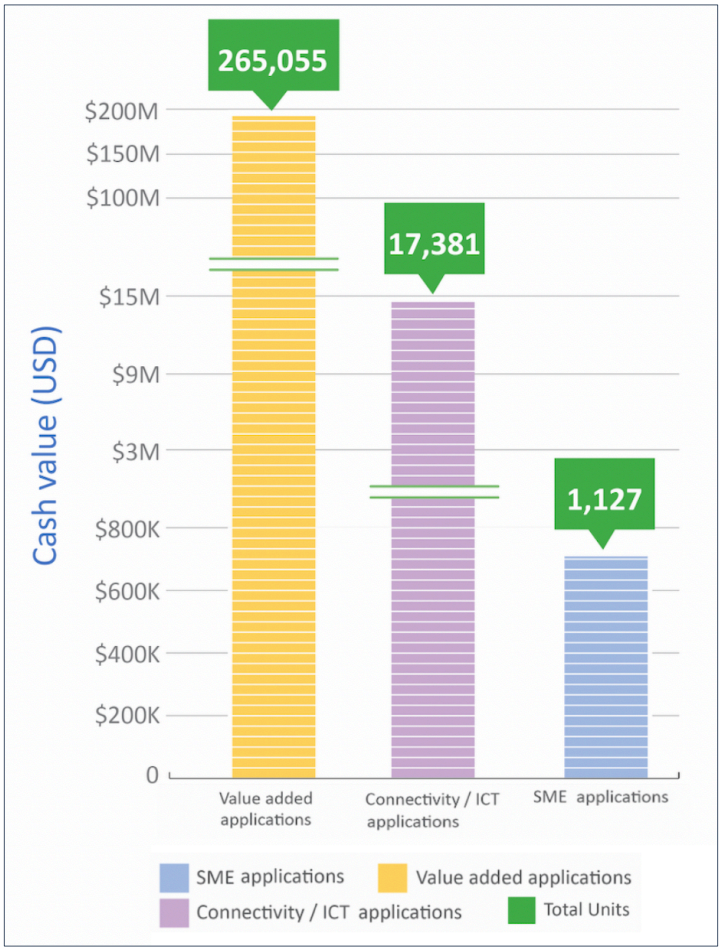


Source: African Solar Designs analysis

The estimated annualized cash market potential for Ghana's public/institutional sector in 2018 is USD 6.5 million (**Figure ES-8**). The institutional market segment with the largest potential is water supply (USD 5.7M), followed by healthcare (USD 470K), public lighting (USD 164K) and education (USD 149K). The water supply sector analysis identified off-grid water points such as boreholes and wells that could benefit from solar technology for water pumping. The healthcare sector analysis identified off-grid health facilities categorized by their size (from basic clinics to enhanced health facilities) that could be electrified by stand-alone systems. The education sector analysis identified primary and secondary schools that could be electrified by stand-alone systems. The public lighting analysis assessed the lighting needs for off-grid villages and market centers (excluding street lighting).

According to the analysis, the annualized off-grid solar cash market potential for the productive use sector in 2018 is USD 205.8 million (**Figure ES-9**). The estimated demand from value-added applications represents most of the PUE market potential (USD 190.2M), followed by applications for connectivity (USD 14.9M) and SMEs (USD 704K).

Figure ES-9: Estimated Off-Grid Solar Cash Market Potential for Productive Use Sector



Source: African Solar Designs analysis

The value-added applications that were analyzed include solar pumping for agricultural irrigation, solar powered milling and solar powered refrigeration. The assessment utilized a series of inputs, including data from the UN's Food and Agriculture Organization on national agricultural production, as well as applicable solar technologies to support income generation for small shareholder farmers (i.e. solar pumps, mills, and refrigeration systems). Access to energy for agriculture is critical for the country's economic development, particularly given the sector's importance to GDP.

Off-grid solar power supports a wide range of connectivity applications, including mobile phone charging, wi-fi servers, banks, mobile money kiosks, and telecommunications towers. Mobile phone and internet connectivity are also necessary pre-cursors to mobile money and PAYG solutions in the off-grid solar sector. The market sizing examined mobile phone network coverage as well as rates of mobile phone ownership and mobile internet penetration to estimate the market potential for mobile phone charging enterprises (stations/kiosks).

The calculation of the estimated off-grid solar market for SMEs focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit significantly from extended working hours and the use of modern appliances/machinery. The estimated demand for this market segment is therefore intended to provide a baseline for future research, as a more robust analysis would be necessary to assess realistic demand from all SMEs.

It should be noted that the Task 2 market sizing assesses the total *potential* demand for off-grid solar, as well as variables that affect demand, such as changes in population density, household income, expansion of national grids and access to finance, among other factors. This data will support policymakers and practitioners as they assess market potential over time. However, the quantitative demand estimate has not been revised to reflect *realistic* market potential. Many other factors and market failures will prevent the full realization of this total market potential, and these will vary by market segment.

For household demand, the off-grid solar market is already tangible. Still, many factors will affect household demand for solar products, such as distribution realties, consumer education, competing economic priorities for households, financial shocks, etc. The institutional market will be affected largely by government and donor budget allocations along with the potential for community-based finance. The productive use market is perhaps the least concrete. Considered a relatively new market segment for the off-grid solar industry, productive use market dynamics are not yet well understood. The ability to realize potential productive use market demand will also be affected by many of the factors that commonly determine enterprise prospects in the country, including infrastructure, rural distribution, marketing, access to finance, insecurity, regulation, etc. The data presented in this report is intended to provide a baseline for future research.

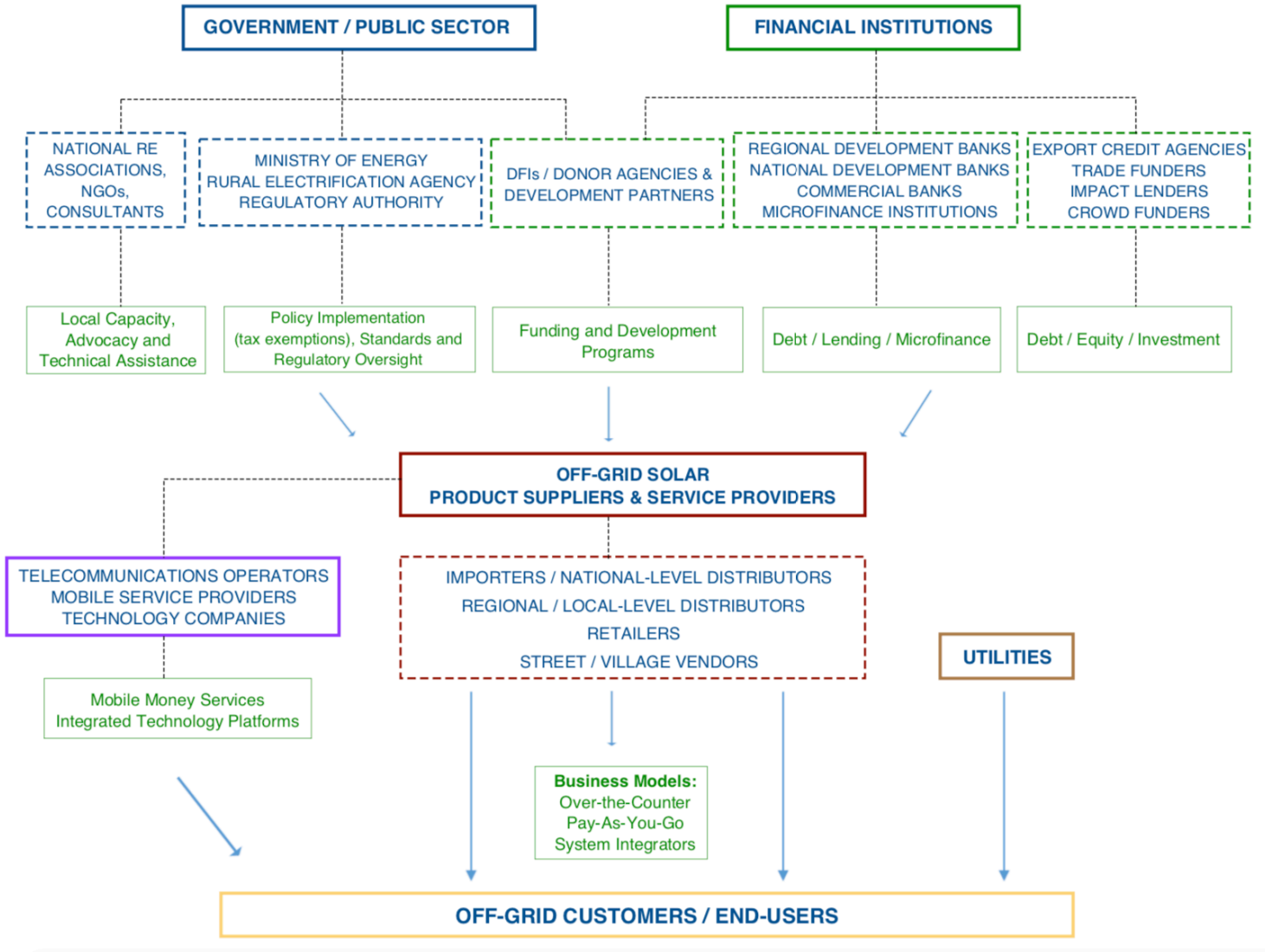
Following the estimates of market demand, this report analyzes the supply chain for off-grid solar products and services in Ghana, which includes a wide range of stakeholders, including importers, distributors, wholesalers, retailers and end-users (**Figure ES-10**). The supply chain is made up of both formal and informal companies that offer a variety of solar products and systems and deploy several business models. Rural households make up the main market for OGS products in the country, as the demand for lighting products and household electrical appliances is growing. Nevertheless, urban households, both electrified and non-electrified, are also a key consumer market, as they may have greater ability to afford solar products and systems.

The country has one of the most dynamic off-grid solar markets in the region. According to figures publishing by GOGLA, Ghana accounted for 10% of sales volume and 12% of sales revenue in West Africa during the period 2016-2017.

The off-grid solar supply chain faces several barriers, including competition from the informal market. The widespread sale of low-quality, uncertified products undermines consumer confidence in solar equipment, undercuts the prices of sellers of quality-verified products and hinders overall OGS market growth. There are also a number of interrelated challenges and capacity building needs of the supply chain, including financial, capacity, awareness and regulatory challenges.

Ghana's nascent solar market is poised to grow if requisite technical assistance is provided to the supply chain. To operate effectively, companies need a significant amount of both local and international technical and financial expertise, as well as an ability to make practical decisions about their operations. Companies must manage a number of technical competency requirements, including the selection of business models, importation and distribution channels, solar PV technologies, as well as the design and implementation of associated marketing instruments and related initiatives.

Figure ES-10: Off-Grid Solar Market and Supply Chain Overview



Source: GreenMax Capital Advisors

Local industry and supply-chain stakeholders who participated in the Task 2 focus group discussions and surveys identified the following key barriers to and drivers of OGS market growth in Ghana:

Key Barriers to Off-Grid Solar Market Growth
• Low consumer purchasing power and lack of consumer financing options
• Low levels of consumer awareness of solar solutions, particularly in rural areas
• Lack of financing for solar companies
• Informal sector competition and market spoilage
• Inadequate local capacity/qualified technicians to maintain systems
• High transaction costs associated with equipment inventory, distribution, importation, taxation etc.
• Insufficient or fragmented market data on consumer electricity needs, usage or experience
Key Drivers of Off-Grid Solar Market Growth
• Strong off-grid electricity demand
• Government policy and action is supportive of the industry, which helps attract investment to the market (e.g. NES)
• Growing penetration of mobile money services allows OGS companies to increasingly utilize integrated technology platforms and innovative business models to offer PAYG consumer financing solutions to the market
• Extensive private sector engagement in development of the off-grid sector, with companies adopting new business models and strategies to attract external investment and expand their operations
• Strong donor presence and support from the international development community provides confidence that the market will continue to receive financial, policy and technical support necessary to develop (e.g. CEADIR, SUNREF)

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

Access to financing is critical for off-grid solar market growth. Solar companies need financing for working capital needs, while off-grid solar consumers need financing for the purchase of systems. This report analyzes the willingness and capacity of national and regional financial institutions to provide financing to businesses and consumers in Ghana and throughout the region to support development of the OGS sector. In addition to commercial banks and microfinance institutions, impact investors and crowd funders are also active in several markets across the region.

Financial inclusion has been growing steadily in Ghana, largely due to the growth of digital financial services and an increase in the usage of mobile money accounts. The share of the country's adult population with an account at a financial institution and/or with a mobile money service provider increased from 29% of the population in 2011, to 41% in 2014, and reached 58% in 2017, driven mainly by the proliferation of mobile money services. Despite this improvement, there is still a significant gender gap in rates of access to financial services, as women in Ghana are 8% less likely than men to have an account at a financial institution or with a mobile money service provider.[28] It is worth noting, however, that rates of access to financial services for women in Ghana (54% in 2017) remain significantly higher than other countries the region and higher than most countries in Sub-Saharan Africa.

Expanding digital financial services, especially mobile money, can create new opportunities to better serve women, the lower-income population, and other groups that are traditionally excluded from the formal financial system. Moreover, mobile money technology also plays a critical role in the application of off-grid solar solutions, particularly for PAYG systems that rely on the interoperability between digital financial services and stand-alone solar devices.

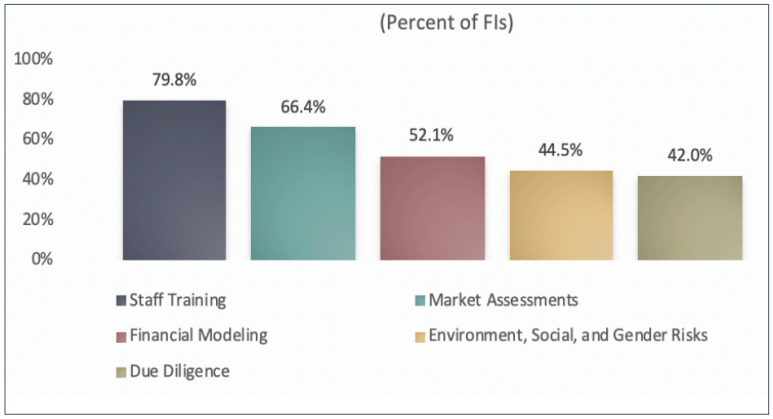
Local FIs are increasingly becoming more aware of the opportunities in the off-grid sector through various engagements with Government and donor-funded programs. These include the Energy Commission's National Rooftop Solar Programme (NRSP), the Ghana Energy Development and Access Project

[28] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., and Hess, J., "The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution," World Bank, (2017): http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf

(GEDAP), AFD's Sustainable Use of Natural Resources and Energy Finance (SUNREF) West Africa program, and the recently completed USAID Climate Economic Analysis for Development, Investment, and Resilience (CEADIR) program.

According to the Task 3 survey of financial institutions in Ghana and across the region,[29] there is strong interest to provide financing to the off-grid solar sector. Respondents identified loan guarantees and credit lines as the most important measures to reduce market entry risks for lenders and stimulate FI engagement in the sector. Surveyed FIs also identified several areas of internal capacity that require improvement in order to lend (or increase lending) to the OGS sector (**Figure ES-11**). The most common need among FIs was training for bank staff, which includes *inter alia* assistance to originate deals and appropriately assess the credit risk of off-grid solar firms and projects, due diligence support to qualify products and approve vendors, and targeted support for new lenders to the sector with product structuring and development as well as building deal-flow. Technical assistance for solar enterprises (as is envisioned under Component 1B of ROGEP) will also be necessary, as entrepreneurs often do not have proper financial management and accounting systems in place, are unable to present quality financial models and lack the expertise required to structure their companies to take on debt obligations.

Figure ES-11: Financial Institution Needs to Increase Off-Grid Solar Lending



Source: Financial Institution survey; Stakeholder interviews; GreenMax Capital Advisors analysis

Gender inclusiveness is also a key component of this market assessment, and the key findings of the gender analysis are presented throughout this report. Given that the off-grid market is only beginning to emerge in Ghana, women are not yet highly engaged in the sector. The overall lack of inclusive participation in the off-grid space is attributable to a wide range of factors. A 2018 survey conducted by IRENA found that nearly three-quarters of respondents cited cultural and social norms as the most common barrier to women's participation in expanding energy access, which reflects the need for gender mainstreaming (**Figure ES-12**). More than half of the women surveyed in Africa identified a lack of skills and training as the most critical barrier, compared to just one-third of respondents globally.[30] The same survey found that access to necessary technical, business or leadership skills development programs was the single most important measure that could be taken to improve women's engagement in energy access. Over half of survey respondents also highlighted the need to integrate gender perspectives in energy access programs, mainstream gender in energy policies and to enhance access to financing for women (**Figure ES-13**).[31]

[29] The results are based on feedback from a total of 121 FIs (including commercial banks, microfinance institutions and other non-bank FIs) that were interviewed across the 19 countries.
[30] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[31] Ibid.

Figure ES-12: Key Barriers to Women's Participation in Energy Access

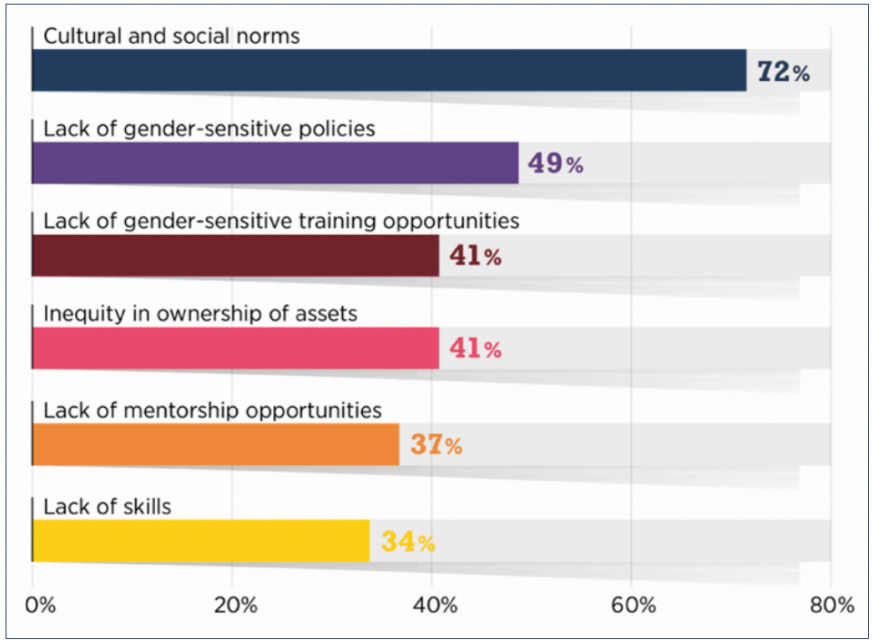
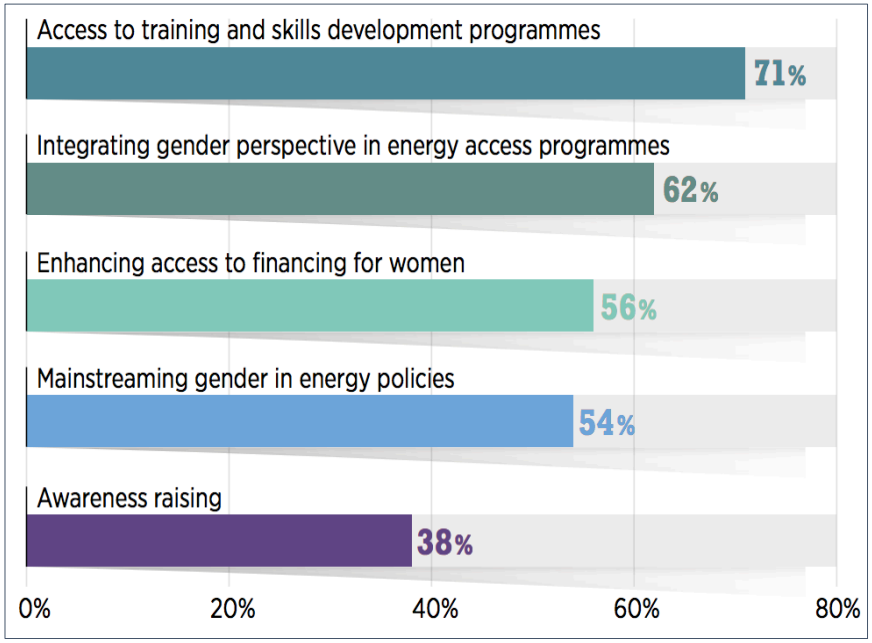


Figure ES-13: Measures to Improve Women's Engagement in Energy Access



Source: International Renewable Energy Agency

The gender analysis undertaken in Ghana corroborated many of these findings and revealed several interrelated challenges that women face in the off-grid sector, including lack of access to skills development, technical capacity building, and education/training; lack of access to capital, asset ownership, collateral and credit (e.g. to start a business); and low rates of financial literacy due to a lack of education and information available to women on access to financial resources.

A number of initiatives exist that seek to address some of these challenges and help improve gender inclusion in the country's energy and off-grid sectors. For example, in 2018, ECREEE partnered with AfDB to launch a regional workshop to advance the participation of women in the renewable energy sector. The program intends to address the lack of female inclusion in the energy value chain, as women represent only 2% of energy sector entrepreneurs in West Africa. The joint initiative ultimately seeks to develop a pipeline of investment-ready, women-owned energy businesses across the region, including in Ghana.[32]

[32] "Feasibility study promotes women's participation in energy transition," ESI Africa, (7 May 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

I. STATE OF ENERGY ACCESS AND ENABLING MARKET ENVIRONMENT

This section begins with a brief introduction of key macroeconomic and social indicators in Ghana (**Section 1.1**). This is followed by an overview of the country's existing energy sector (**Section 1.2**), with a focus on the status of energy access, including an assessment of both the on-grid and off-grid markets, a least-cost electrification analysis and a review of gender policies. **Section 1.3** examines national energy policy and regulation vis-à-vis the off-grid solar market, including detailed analysis of the existing framework for stand-alone systems[33] in Ghana as well as gaps in the framework. **Section 1.4** is a summary of all relevant national and donor-funded development initiatives in the off-grid sector. **Annex 1** provides an overview of the Task 1 methodology.

1.1 Country Overview

Ghana is a lower middle-income country with a strong market-based economy with few barriers to trade and investment compared to other countries in the region. The economy recovered in 2017 following a slowdown in growth in recent years as a result of domestic and external negative shocks. Real GDP growth reached 8.5% in 2017 and is projected to grow by 7% in 2018, supported by an increase in crude oil production.[34] Poverty has steadily declined in Ghana but still afflicts more than one-third of the country's rural inhabitants. While the country has transitioned to a services-oriented economy, about half of the labor force remains in the agricultural sector.

Table 1: Macroeconomic and Social Indicators

Population	28.8 million[35]
Urban Population	55% of total
GDP	USD 59 billion
GDP growth rate	8.5%
GNI per capita*	USD 1,880
Unemployment rate	2.36%
Poverty rate	24.2% (2012)
Urban	10.6%
Rural	37.9%
Currency	Ghanaian cedi (GHS)
Official language	English
Natural resources	Hydrocarbons (oil and gas); agricultural (cocoa); ores (gold, diamonds, manganese)

* World Bank Atlas method (current USD)[36]
All figures from 2017 unless otherwise indicated
Source: AfDB and World Bank

1.2 Energy Market

1.2.1 Energy Sector Overview

The energy sector in Ghana has been undergoing a transition for several years, as the electricity market has been restructured to unbundle generation, transmission and distribution assets and increase private sector participation, while the Government of Ghana (GoG or "the Government") has made a series of corresponding institutional changes. In 2014, the GoG split up the Ministry of Energy and Petroleum and

[33] NOTE: The term "off-grid" as it is widely used throughout this report (e.g. "off-grid sector") refers to both mini-grids and stand-alone systems. When "off-grid solar" or its acronym "OGS" are used, this refers *only* to stand-alone systems and does not include mini-grids
[34] "Ghana Economic Outlook," African Development Bank, (2018): https://www.afdb.org/en/countries/west-africa/ghana/
[35] 50.1% male/49.9% female
[36] "World Bank Open Data: Ghana," World Bank, (2017): https://data.worldbank.org/country/ghana

formed a separate Ministry of Power to manage and oversee electricity production and infrastructure development. In 2017, these entities were again consolidated under the current Ministry of Energy (MoE), which is responsible for energy policy formulation, with input from the Energy Commission (EC) and from the independent Public Utilities Regulatory Commission (PURC). The state-owned utility, Volta River Authority (VRA), is responsible for power generation nationwide. Ghana Grid Company (GRIDCo) was unbundled from VRA in 2008 and is responsible for power transmission, while the Electricity Company of Ghana Limited (ECG) and Northern Electricity Distribution Company (NEDCo), a subsidiary of VRA, manage power distribution in the southern and northern parts of the country, respectively.

In 2010, a Directorate was established within the Ministry to focus exclusively on renewable energy (RE) development, which now receives extensive policy and regulatory support from the GoG, which has made RE a priority. The Government aims to achieve a 10% contribution from RE in the electricity generation mix by 2020.[37] The MoE's medium term policy focus for the energy sector also includes increasing the contribution of RE, particularly in the off-grid sector.[38]

Table 2: Institutional and Market Actors in the Energy Sector

Institution / Company	Role in the Energy Sector
Ministry of Energy (MoE)	Ministry responsible for energy policy formulation, implementation, monitoring and evaluation. Also responsible for supervision of national utilities and the country's electricity generation, transmission, and distribution system and for the implementation of the National Electrification Scheme (NES), which seeks to make electricity access universal in the long-term.
Volta River Authority (VRA)	State-owned utility under the MoE and is responsible for electricity generation for residential, commercial and industrial use across Ghana.[39] Through its wholly-owned subsidiary, Northern Electricity Distribution Company (NEDCo), VRA is also responsible for electricity distribution in the northern sector of Ghana.
Electricity Company of Ghana Limited (ECG)	State-owned utility under the MoE and is responsible for distribution of electricity in the southern part of Ghana (namely, Ashanti, Central, Eastern, Greater Accra, Volta, and Western Regions) covering approximately 80% of the population.
Ghana Grid Company (GridCo)	State-owned transmission company responsible for (i) undertaking transmission of electricity from suppliers (generating companies) to bulk customers, which include ECG, NEDCo and the Mines; (ii) providing fair and non-discriminatory transmission services to all power market participants; (iii) acquiring and managing assets, facilities and systems required to transmit electricity; (iv) providing metering and billing services to customers; (v) carrying out transmission system planning and implementing necessary investments to provide the capacity to reliably transmit electricity; and (vi) managing the Wholesale Power Market.
Energy Commission (EC)	Regulatory authority that consists of seven Commissioners appointed by the President of Ghana required to regulate, manage, and develop the utilization of energy resources in Ghana and provide the legal, regulatory and supervisory framework for all providers of energy in the country. The EC is also an energy planning entity that grants licenses for the transmission, wholesale, supply, distribution, and sale of electricity and natural gas and refining, storage, bulk distribution, marketing, and sale of petroleum products. As a statutory body, the EC gives policy recommendations and related advice to the Minister of Energy.
Public Utility Regulatory Commission (PURC)	Independent regulatory body established to approve tariff rates for electricity customers and to enforce performance standards for energy sector operators in Ghana.
Northern Electricity Distribution Company (NEDCo)	Subsidiary of VRA responsible for electricity distribution in northern parts of Ghana
Enclave Power	Private operator that generates, purchases and distributes electricity in Tema Free Zone.

Source: ECOWAS Center for Renewable Energy and Energy Efficiency

[37] "Infrastructure – Energy," Ghana Investment Promotion Centre, (2018): http://www.gipcghana.com/invest-in-ghana/why-ghana/infrastructure/energy-infrasctructure.html

[38] "Renewable Energy Resources and Potentials in Ghana," Ministry of Power, (2016): https://ambaccra.esteri.it/Ambasciata_Accra/resource/doc/2016/12/renewable_resources_and_potentials_20.12.2016.pdf

[39] In addition to VRA, there are also several privately-owned IPPs that generate electricity in Ghana (not captured in Table 2).

1.2.2 Electricity Access: *Grid and Off-Grid*

Ghana has one of West Africa's highest rates of electricity access, with a national electrification rate of 84% and a rural electrification rate of 71%.[40] As a result, the off-grid market in Ghana differs considerably from most of the countries in the region. Although the Government has prioritized grid extension to un-electrified communities through the National Electrification Scheme (NES), some communities remain without access to electricity either because they are inaccessible or there is not a viable economic model for extending the distribution network. Ghana's Energy Sector Strategy and Development Plan and Renewable Energy Master Plan aim to achieve universal access to electricity by 2030.

1.2.2.1 Off-Grid Market Overview

According to the MoE, around 80% of communities with more than 500 people have access to grid electricity. The remaining communities that are currently without access to electricity are mainly rural communities living on islands in Lake Volta and in isolated lakeside locations. These communities will be best served with distributed energy solutions such as mini-grids and solar home systems (SHS). The main challenges hindering the extension of electrification to these communities include the inaccessibility of the community and lack of a viable economic model. There is thus a need for the development of viable delivery models, tariff structures and supportive policy and regulatory frameworks to properly manage arrangements for the rollout of off-grid solutions in the form of stand-alone systems or mini-grids.[41]

With recent advancements in battery storage technology, more robust system designs, enhanced efficiencies and reduced costs, distributed solar solutions are expected to make significant contributions to economic growth in Ghana. It is expected that small businesses (shops, kiosks, etc.) in off-grid areas will be able to utilize solar for a range of productive uses. For instance, solar power can have a significant impact in providing electricity for value-added applications in rural areas that rely on subsistence agriculture (e.g. in the areas of water pumping and irrigation for agriculture). The GoG has already prioritized renewable energy investments aimed at deploying stand-alone technologies (pico solar and SHS) to support isolated off-grid households and public institutional facilities including schools, health clinics and security outposts.

In 1989, the GoG initiated the NES as its principal policy to extend electricity supply to all parts of the country over a 30-year period from 1990 to 2020. During the first phase of the program, between 1990 and 1995, the Government initiated the electrification of district capital towns and villages. Subsequent phases of the NES prioritized the electrification of communities in five-year blocks according to the economic viability of the projects. In 2007, to supplement the NES, the Government instituted the Self-Help Electrification Programme (SHEP) to assist communities in advancing their connection to the national electricity grid ahead of their scheduled connection time. These initiatives have successfully connected thousands of Ghanaian communities to the national electricity grid.

Subsequently, in 2019, with funding from UNDP and DANIDA, Ghana published a Renewable Energy Master Plan (REMP), which includes a series of targets in five-year blocks through 2030 (**Figure 1**). The REMP intends to add a total of 20 MW of stand-alone solar by 2030 and also aims to support integration of existing stand-alone systems into mini-grids under the country's existing net metering scheme.[42]

[40] "Energy Access Outlook, 2017: From Poverty to Prosperity," IEA, (2017): https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
[41] "Ghana: Mini-Grids for Last-Mile Electrification," ESMAP, (2017): http://www.eca-uk.com/wp-content/uploads/2017/08/ESMAP-Ghana_Mini_grids_for_last_Mile_Electrification_Optimized.pdf
[42] Ghana Renewable Energy Master Plan: https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/UNDP_GH_SUS_DEV_REN_MASTER_PLAN_2019.pdf

Figure 1: Ghana Renewable Energy Master Plan – Solar Energy Targets through 2030[43]

REMP IMPLEMENTATION PLAN - RE TARGETS UP TO 2030										
Renewable Energy Technologies	Reference 2015		Cycle I (2019-2020)		Cycle II (2021-2025)		Cycle III (2026-2030)		Cumulative in 2030	
	No. of units	MWp	No. of Units	MWp	No. of Units	MWp	No. of Units	MWp	No. of Units	MWp
Solar Energy										
Solar Utility Scale	-	22.5	-	130	-	195	-	100	-	447.5
Distributed Solar PV		2		18		80		100		200
Standalone Solar PV	-	2	-	8	-	5	-	5	-	20
Solar Street/Community lighting	-	3	-	4	-	4	-	14	-	25
Solar Traffic signals (% of total traffic signals installed in the country)	14	3	11	-	15	-	20	-	60	-
Solar Lanterns	72,000	-	128000	-	300000	-	500000	-	1000000	-
Solar irrigation	150	2.8	6000	6	20000	20	20000	20	46150	48.8
Solar Crop Dryers	70	-	80	-	250	-	300	-	700	-
Solar Water Heaters	4,700	-	15300	-	50000	-	65000	-	135000	-

Source: Ghana Renewable Energy Master Plan

[43] Ghana Renewable Energy Master Plan: https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/UNDP_GH_SUS_DEV_REN_MASTER_PLAN_2019.pdf

A multitude of public agencies and private companies have been engaged in development of Ghana's off-grid market (see **Section 1.3.4.1**). It is estimated that through Government-sponsored programs, over 21,600 SHS were deployed in Ghana through 2014, including 16,800 systems (about 8,000 solar lanterns) financed through the GoG rural electrification/solar program (GEDAP). Private solar companies operating independently of Government initiatives had collectively installed at least 50,000 SHS through 2015 (see **Section 2.4**).[44]

The Government's medium-term plan is to provide electricity to island and lakeside communities that are not connected to the national grid in the immediate future.[45] In 2016, under the Scaling-up Renewable Energy Investment Plan (SREP-IP), the MoE announced that USD 230 million has been designated to support growth of off-grid communities across the country using RE sources.[46] During a government-sponsored off-grid challenge initiative launched in 2014, seven solar companies in the country were awarded with grants of up to USD 100,000 each to provide off-grid solutions.[47] The Government has also committed to install 200,000 solar systems to provide power to households, commercial as well as government facilities in urban and selected non-electrified communities.[48]

1.2.2.2 Demand and Supply/Generation Mix

While installed capacity exceeds 4 GW, demand for power is steadily increasing in Ghana, constraining the country's supply.[50] Ghana generated about two-thirds of its electricity from thermal generation in 2017, with most of the remaining capacity coming from hydropower. The actual availability of electricity rarely exceeds 2,400 MW due to changing hydrological conditions, inadequate fuel supplies, and poor network infrastructure. Installed solar PV capacity (42.6 MW) accounts for about 1% of the generation mix, with 2.5 MW from a plant owned by VRA in Navrongo, and two 20 MW plants owned by BXC Ghana, commissioned in 2016 and 2018. The GoG aims is to increase the share of RE in the generation mix to 10% by 2030.[51]

Table 3 : Electricity Sector Indicators, 2017[49]

Installed Capacity	4,419 MW
Thermal	2,796 MW
Hydropower	1,580 MW
Renewable (non-hydro)	42.6 MW
National electrification rate (2016) Urban electrification rate Rural electrification rate	84% 95% 71%
Population without access	4.6 million
Households without access	1.3 million
Electrification target	Universal access by 2030

Source: Energy Commission, IEA and World Bank

With demand for power growing steadily, increasing supply to the grid is crucial. Demand grew over 175% between 2004 and 2014 and is expected to continue growing at similar rates in the coming decade.[52] In 2016, the power system recorded a system peak load of 2,087 MW, which amounted to an increase of 154

[44] "Evaluation of the Financial and Economic Combination of SHS and Mini-Grid Systems in Ghana," African Development Bank / ITP, (July 2015): https://www.african-ctc.net/fileadmin/uploads/actc/Documents/GHANA_SE4All_evaluation_of_SHS_minigrids.pdf
[45] "Universal Access to Energy: Ghana's Rural Electrification – A Case Study," Ministry of Energy & Petroleum Ghana, (2013): https://www.engerati.com/sites/default/files/13h30%20Barfour%20Tues%20T%26DSmart.pdf
[46] "Ghana Renewables Readiness Assessment Report," IRENA (2015): http://www.irena.org/DocumentDownloads/Publications/IRENA_RRA_Ghana_Nov_2015.pdf
[47] "Ghana promotes renewable energy in off-grid communities," ESI Africa, (April 2018): https://www.esi-africa.com/ghana-promotes-renewable-energy-in-off-grid-communities/
[48] "Ghana to install 200,000 solar systems," ESI Africa, (March 2018): https://www.esi-africa.com/ghana-install-200000-solar-systems-says-president-akufo-addo/
[49] See **Section 2.1** for more details on households/population without access to electricity.
[50] "Ghana Power Africa Fact Sheet," USAID, (2018): https://www.usaid.gov/powerafrica/ghana
[51] "Ghana promotes renewable energy in off-grid communities," ESI, (2018): https://www.esi-africa.com/ghana-promotes-renewable-energy-in-off-grid-communities/
[52] "Electric Power Consumption (kWh per capita): Ghana," World Bank, (2018): https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?locations=GH&view=chart

MW (8%) over the 2015 system peak of 1,933 MW.[53] Ghana meets electricity demand both from its domestic installed capacity as well as through imports from Côte d'Ivoire in the West African Power Pool (WAPP).

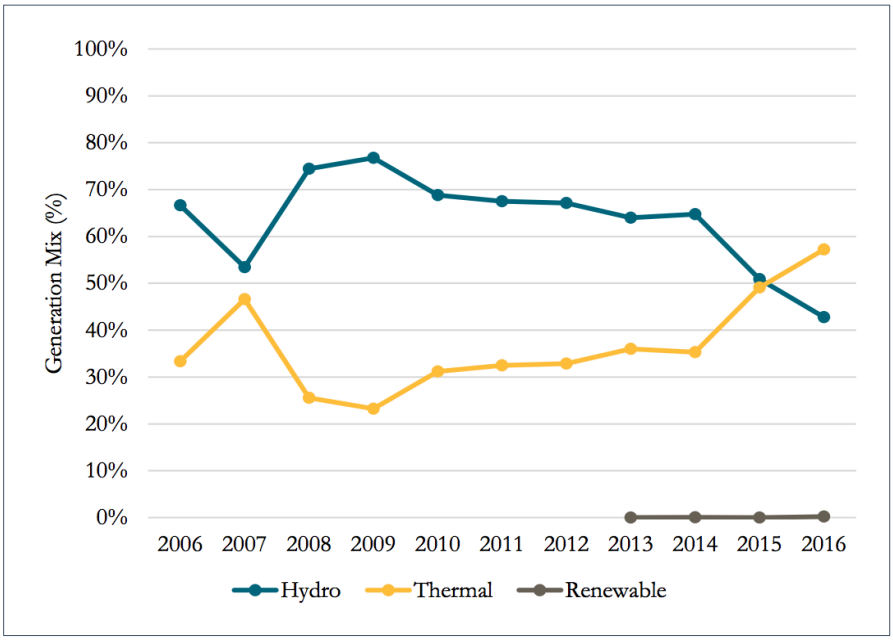
Table 4: Current and Planned Installed Capacity[54]

Installed Capacity (MW)	2017	2020 (planned)
Thermal	2,796	no data
Large hydro	1,580	1,580
Solar	42.6	218
Wind	-	20
Total Installed Capacity (MW)	**4,418.6**	**-**
Total thermal	2,796	no data
Total renewable energy	1,622.6	1828

Source: SEforALL National Renewable Energy Action Plan

Available data indicates that the potential for solar energy generation in Ghana is substantial. This provides great opportunities for the wider implementation of off-grid solar. Under the Rooftop Solar Program, the Energy Commission aims to install at least 200 MW of rooftop PV capacity in the medium term, expanding far beyond Ghana's current total grid-connected solar capacity of about 23 MW.[55]

Figure 2: Electricity Generation Mix[56]



Source: Energy Commission of Ghana

[53] "2017 Energy (supply and demand) outlook for Ghana," Energy Commission Ghana (2017)
[54] "Ghana National Renewable Energy Action Plan," ECREEE / SEforALL, (2015): http://se4all.ecreee.org/sites/default/files/ll.ghana_nreap_vs_final.pdf
[55] Bellini, E., "Ghana to launch rooftop solar program in 2018," PV Magazine (December 18, 2017): https://www.pv-magazine.com/2017/12/18/ghana-to-launch-rooftop-solar-program-in-2018/
[56] Kumi, E. N., "The Electricity Situation in Ghana: Challenges and Opportunities," Center for Global Development, (September 2017): https://www.cgdev.org/sites/default/files/electricity-situation-ghana-challenges-and-opportunities.pdf

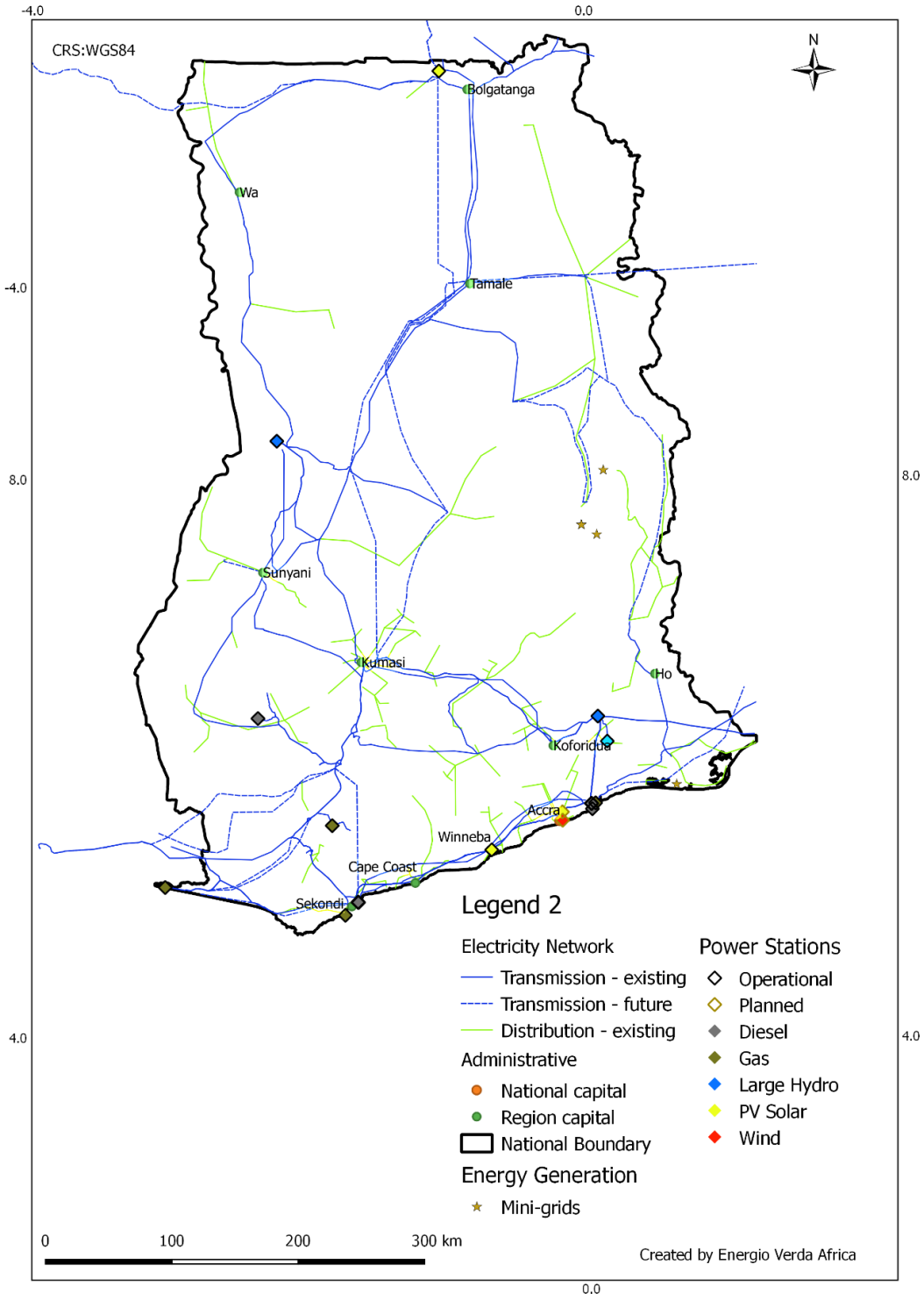
1.2.2.3 Transmission and Distribution Network

There are three distribution companies operating in Ghana. Electricity Company of Ghana (ECG) serves the southern region, Northern Electricity Distribution Company (NEDCo) serves the northern region, and Enclave Power serves companies in the Tema free zone enclave.[57] GRIDCo owns and operates the country's extensive transmission grid (**Figure 3**). In Ghana, an estimated 400 MW of generation capacity is currently unavailable due to grid maintenance issues.[58] Moreover, the country's electricity service is not always reliable (**Figure 4**).

It has been reported that about 21.7% of gross electricity generated over the last decade has been lost annually through losses in the transmission and distribution network. Whereas transmission losses for this period only averaged 3.9%, distribution losses, which also include commercial losses, accounted for 16.2% annually by ECG. Non-technical losses, estimated to be about 14%, are mainly associated with illegal connections and unpaid consumption.[59]

[57] "Infrastructure – Energy," GIPC, (2018): http://www.gipcghana.com/invest-in-ghana/why-ghana/infrastructure/energy-infrasctructure.html
[58] "ECOWAS Renewable Energy and Energy Efficiency Status Report," ECREEE, (2014): http://www.ren21.net/Portals/0/documents/activities/Regional%20Reports/ECOWAS_EN.pdf
[59] "National Electrification Scheme," Ministry of Energy, (2010): http://www.mida.gov.gh/pages/view/NES_Master_Plan_Review_Executive_Summary_Main_Report.pdf/111

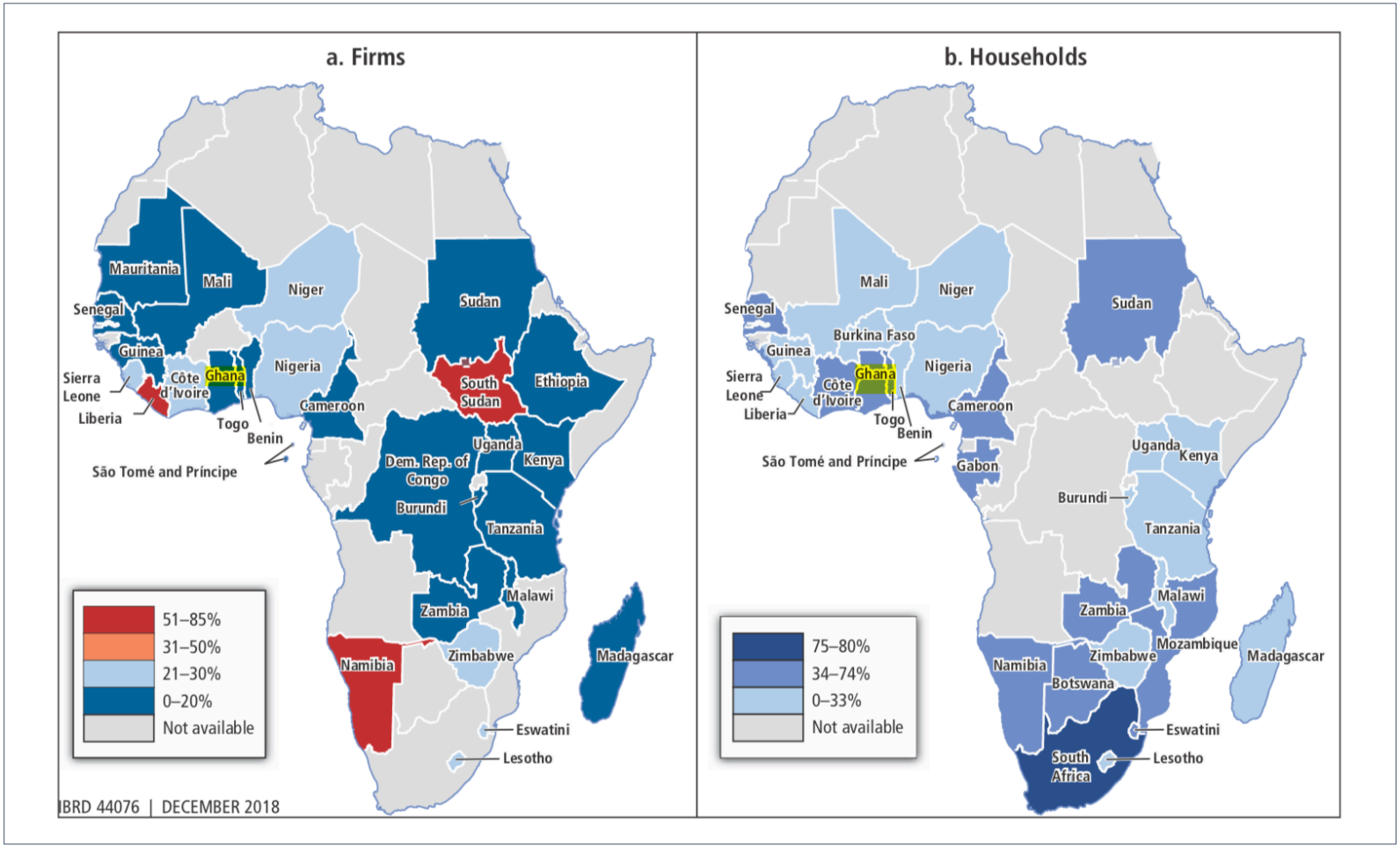
Figure 3: Electricity Transmission and Distribution Network[60]



Source: Energio Verda Africa GIS analysis

[60] See **Annex 1** for more details, including data sources.

Figure 4: Access to Reliable Electricity by Firms and Households in Africa[61]



Source: World Bank Enterprise Surveys, 2013-2017 and Afrobarometer Household Surveys, 2014-2015

The maps in **Figure 3** illustrate the share of firms (Panel a) and households (Panel b) reporting access to a reliable supply of electricity across Africa. In Ghana, fewer than 20% of surveyed firms and about half of surveyed households reported having reliable access to electricity.

[61] Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact," AFD and World Bank, Africa Development Forum, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y

1.2.2.4 Least-Cost Electrification Analysis

A least-cost electrification analysis has been performed to assess the potential development of electricity access in Ghana through 2023 and through 2030 ("Scenario 2023" and "Scenario 2030").[62] The analysis identifies the scale of market opportunities for off-grid stand-alone solar electrification. A brief summary of the approach and methods used, main assumptions and key results of the analysis in Ghana are outlined below. Additional geographic information system (GIS) information, including categorizations, key definitions, and datasets are included in **Annex 1**.

- **Methodology**

The analysis used geospatial techniques to determine the least-cost electrification options for settlements across Ghana based on their proximity to electrical infrastructure, population density or nodes of economic growth.

For the scenario 2023 analysis, it is assumed that widespread densification of the existing electrical grid will connect settlements within 5 km of existing grid lines (according to WAPP densification plans).[63] Beyond this area, the likely candidates for electrification by mini-grid systems are settlements that are relatively dense (above 350 people/km^2) and have active local economies, evidenced by the presence of social facilities and by their proximity to other settlements already with electricity access (i.e. within 15 km of night-lights areas). All remaining settlements – those in areas of lower population density (below 350 people/km^2) or far from the national grid – are defined as candidates for off-grid stand-alone systems.

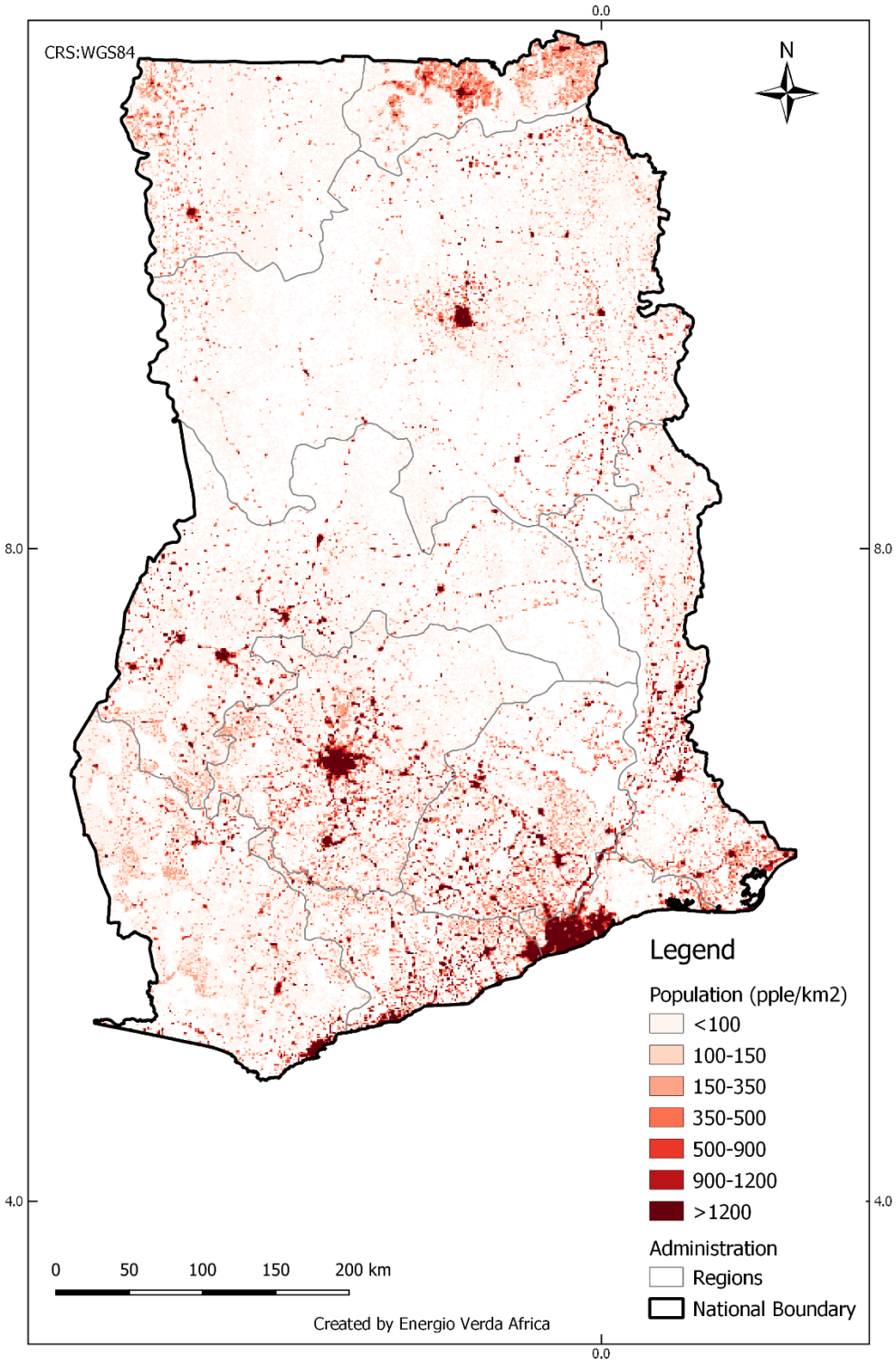
For the scenario 2030 analysis, it is assumed that the grid and the reach of grid densification efforts will extend far beyond the existing network. Hence, settlements that are within 15 km of current lines (average densification distance announced by utilities across West Africa in a 10-year timeline in personal interviews) and 5 km of future planned line extensions (HV lines only were available for the analysis) are assumed to be connected. For mini-grids, future economic development – which will allow new settlements to grow sufficiently to become mini-grid candidates – is assumed to occur in settlements within 1 km of mini-grid settlements (average distance of mini-grid coverage of different developers) identified in the scenario 2023 analysis, as well as within 15 km of economic growth centers – airports, mines and urban areas. All other settlements are defined as candidates for off-grid stand-alone systems.

Given the lack of low voltage distribution line data, it is necessary to approximate areas where un-electrified settlements in close proximity to the grid exist. The analysis therefore focuses on settlements that are within 5 km of the high and medium voltage network, but that are located beyond 15 km of areas with night-time light emissions (indicative of electrification). Settlements in areas of low population density (below 350 people/km^2) that met the above criteria are identified as both being currently un-electrified and unlikely to be electrified within the scenario 2023.[64]

In order to identify the population within each settlement, additional analysis was undertaken to estimate these figures. The current annual national population growth rate of 2.2%[65] was applied to the geospatial analysis to project population figures for scenario 2023 and 2030 analyses.[66] **Figure 5** shows population density across the country, which served as the basis for this analysis.

[62] NOTE: Rather than presenting a 10-year projection through 2028, the analysis conforms to GoG electrification targets for 2030
[63] NOTE: Low-voltage distribution lines were not considered in this analysis and only few of the MV lines (data was unavailable)
[64] Note that this analysis was performed for the five-year scenario but not for the year 2030 scenario due to uncertainties regarding population densities being too high over such a long timeframe
[65] "World Bank Open Data: Ghana," World Bank, (2017): https://data.worldbank.org/indicator/SP.POP.GROW?locations=GH
[66] See **Annex 1** for the results of this analysis as well as more details on the approach / methods used

Figure 5: Population Density, 2015[67]



Source: Energio Verda Africa GIS analysis

[67] See **Annex 1** for more details, including data sources.

- **Results**

Table 5 summarizes the results of the least cost electrification analysis. **Figure 6** and **Figure 7** illustrate the distribution of settlements according to least-cost electrification options under scenarios 2023 and 2030, respectively. The number of households was estimated by using the average household size for the country (3.5 persons/household).[68]

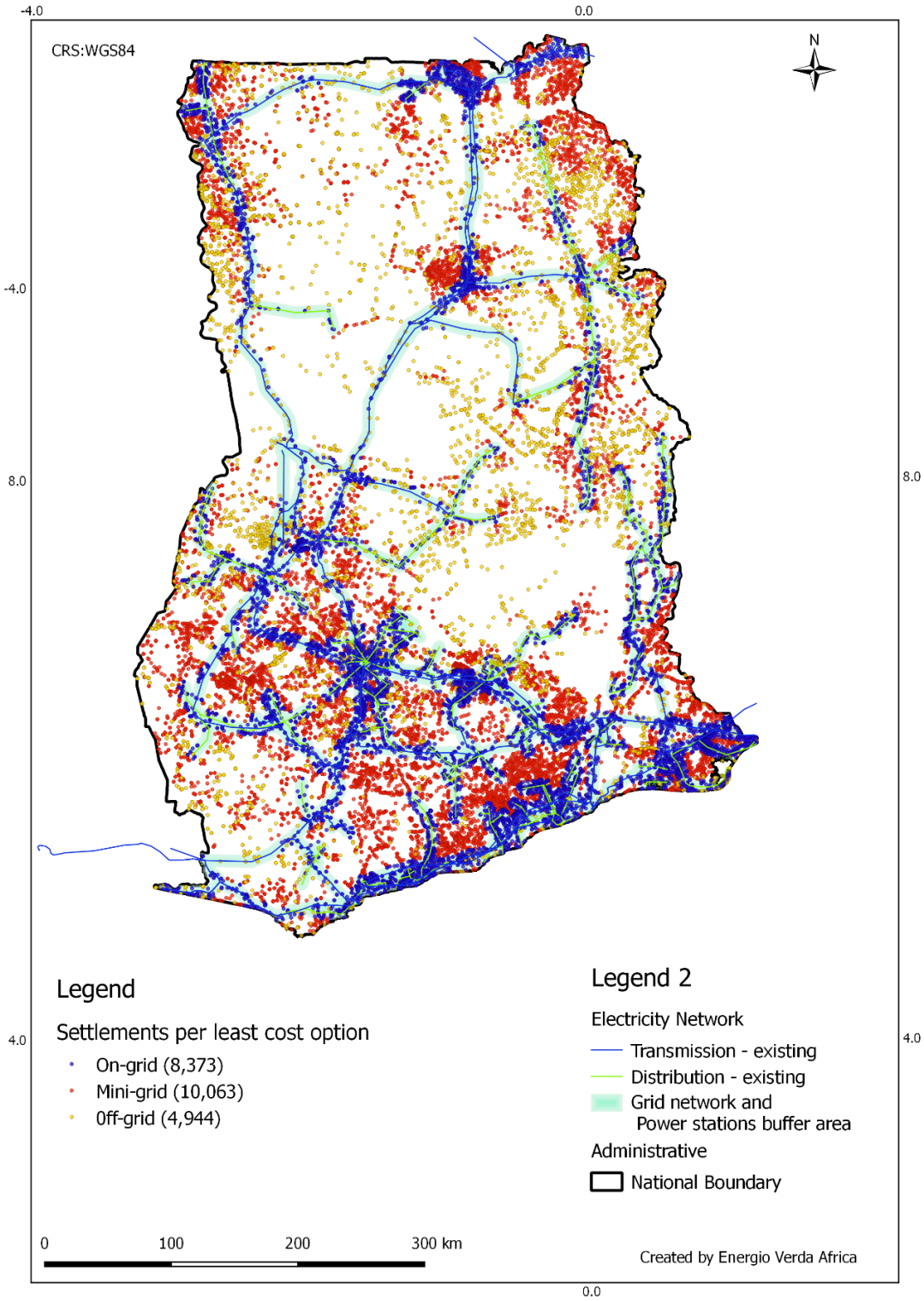
Table 5: Results of Least-Cost Electrification Analysis

Scenario	Indicator	Least-Cost Electrification Option			Grid Vicinity		
		Grid extension	Mini-grid	Off-grid stand-alone systems	Under-grid un-served	Total under-grid	Total outside grid vicinity
Scenario 2023	Number of settlements	8,373	10,063	4,874	1,399	9,772	13,538
	% of settlements	35.9%	43.2%	20.9%	14.3%	41.9%	58.1%
	Total population	20,821,111	7,980,198	3,945,562	1,717,239	22,538,350	10,208,521
	% of population	63.6%	24.4%	12.0%	7.6%	68.8%	31.2%
	Number of households	5,948,889	2,280,057	1,127,303	490,640	6,439,529	2,916,720
Scenario 2030	Number of settlements	18,384	3,329	1,597	Not calculated	18,384	4,926
	% of settlements	78.9%	14.3%	6.9%	Not calculated	78.9%	21.1%
	Total population	33,823,477	3,006,531	1,305,196	Not calculated	33,823,477	4,311,727
	% of population	88.7%	7.9%	3.4%	Not calculated	88.7%	11.3%
	Number of households	9,663,851	859,009	372,913	Not calculated	9,663,851	1,231,922

Source: Energio Verda Africa GIS analysis

[68] "Household Size and Composition Around the World," United Nations, (2017): http://www.un.org/en/development/desa/population/publications/pdf/ageing/household_size_and_composition_around_the_world_2017_data_booklet.pdf

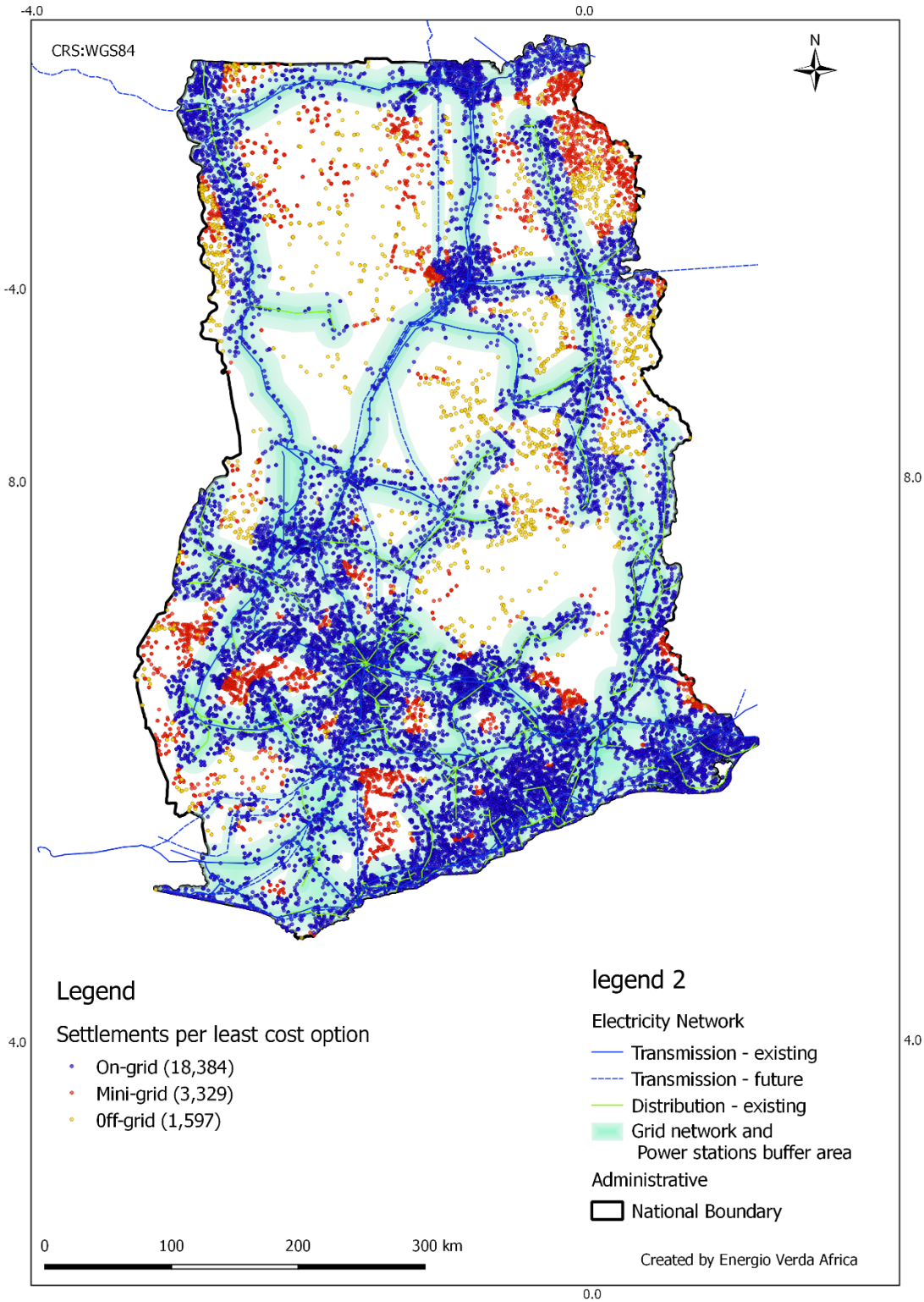
Figure 6: Distribution of Settlements by Least-Cost Electrification Option, 2023[69]



Source: Energio Verda Africa GIS analysis

[69] Displaying identified settlements with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

Figure 7: Distribution of Settlements by Least-Cost Electrification Option, 2030[70]



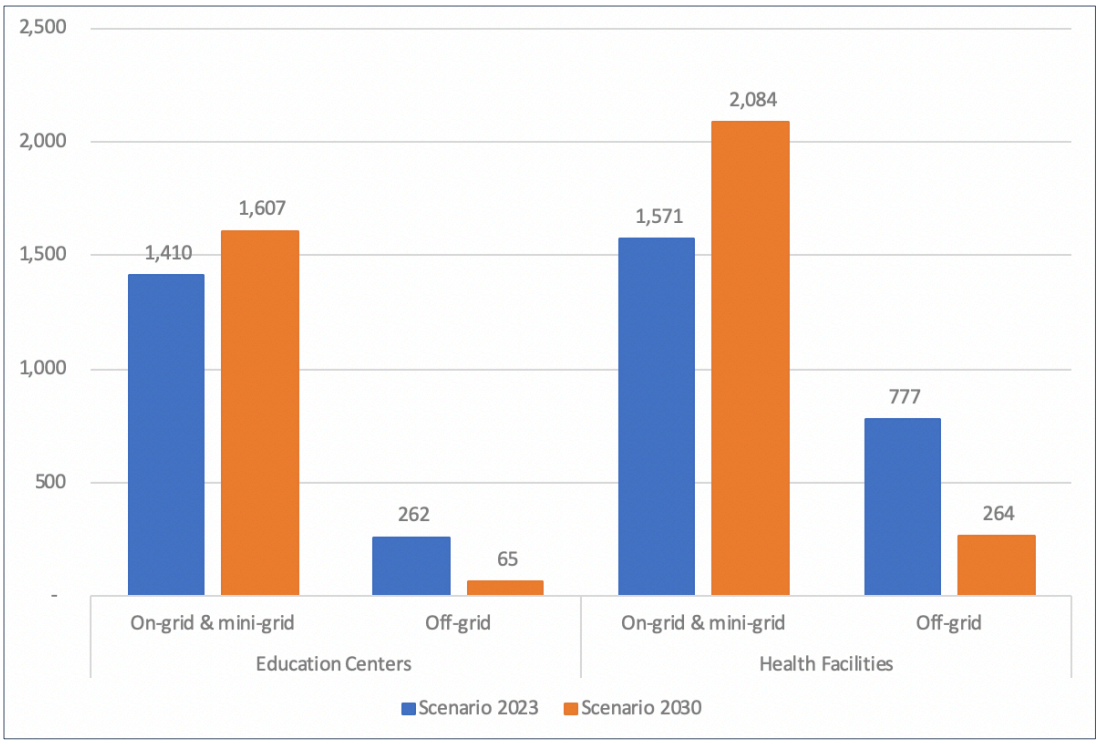
Source: Energio Verda Africa GIS analysis

[70] Displaying identified settlements with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

The analysis also covered the education centers and health facilities that will remain off-grid during the analyzed timeframes. The location of most primary schools and junior high schools was not known for the study and it therefore mainly estimates the off-grid potential for senior high schools, colleges and vocational training centers.[71]

Figure 8 summarizes the number of education centers and health facilities that may be electrified via on-grid or mini-grid solutions or that are suitable for off-grid stand-alone solutions in scenarios 2023 and 2030. **Figure 9** and **Figure 10** illustrate the distribution of potential off-grid social facilities across the country under the two scenarios.

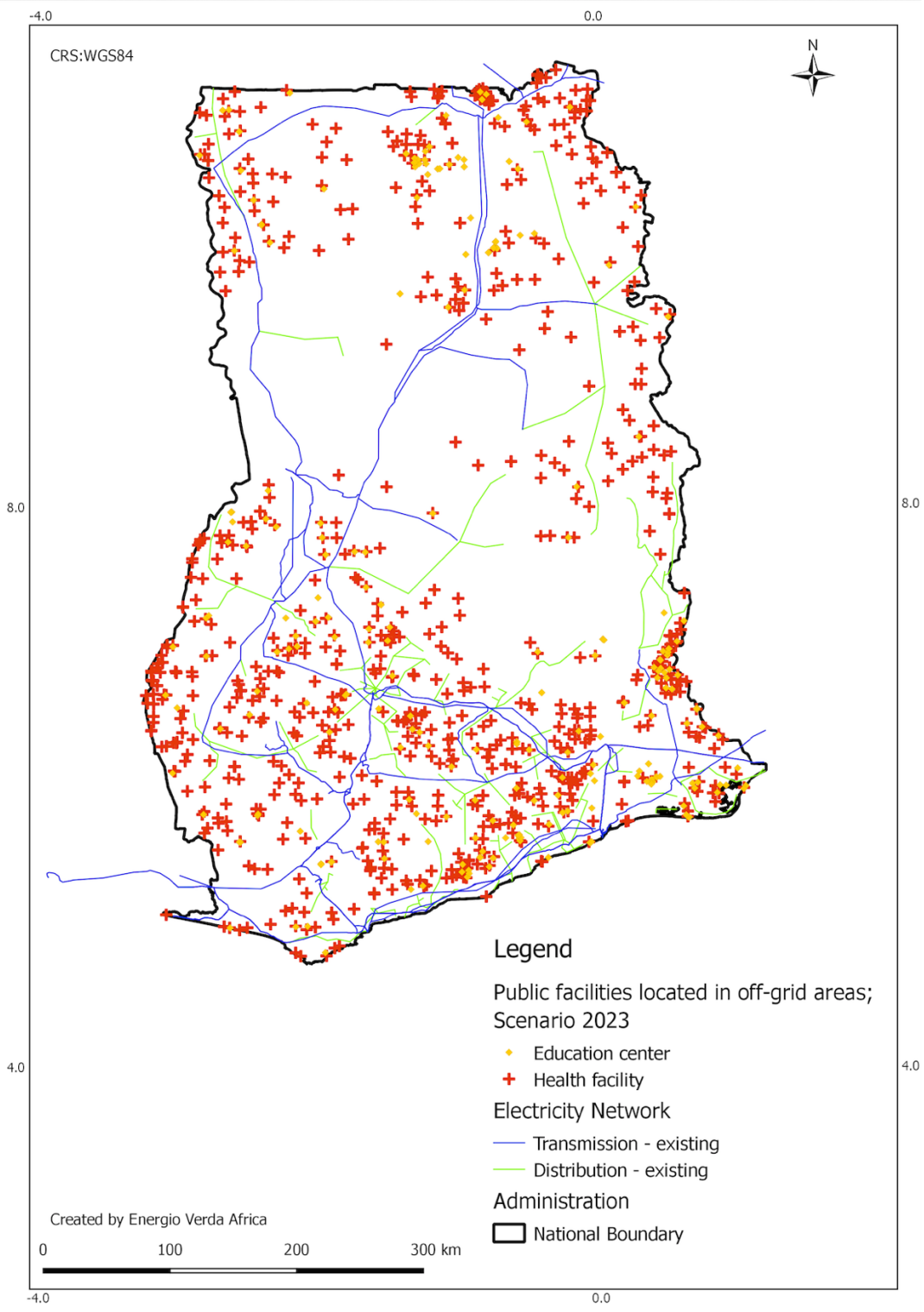
Figure 8: Identified Social Facilities for On-Grid, Mini-Grid and Stand-alone Solutions, 2023 and 2030



Source: Energio Verda Africa GIS analysis

[71] See **Annex 1** for more details.

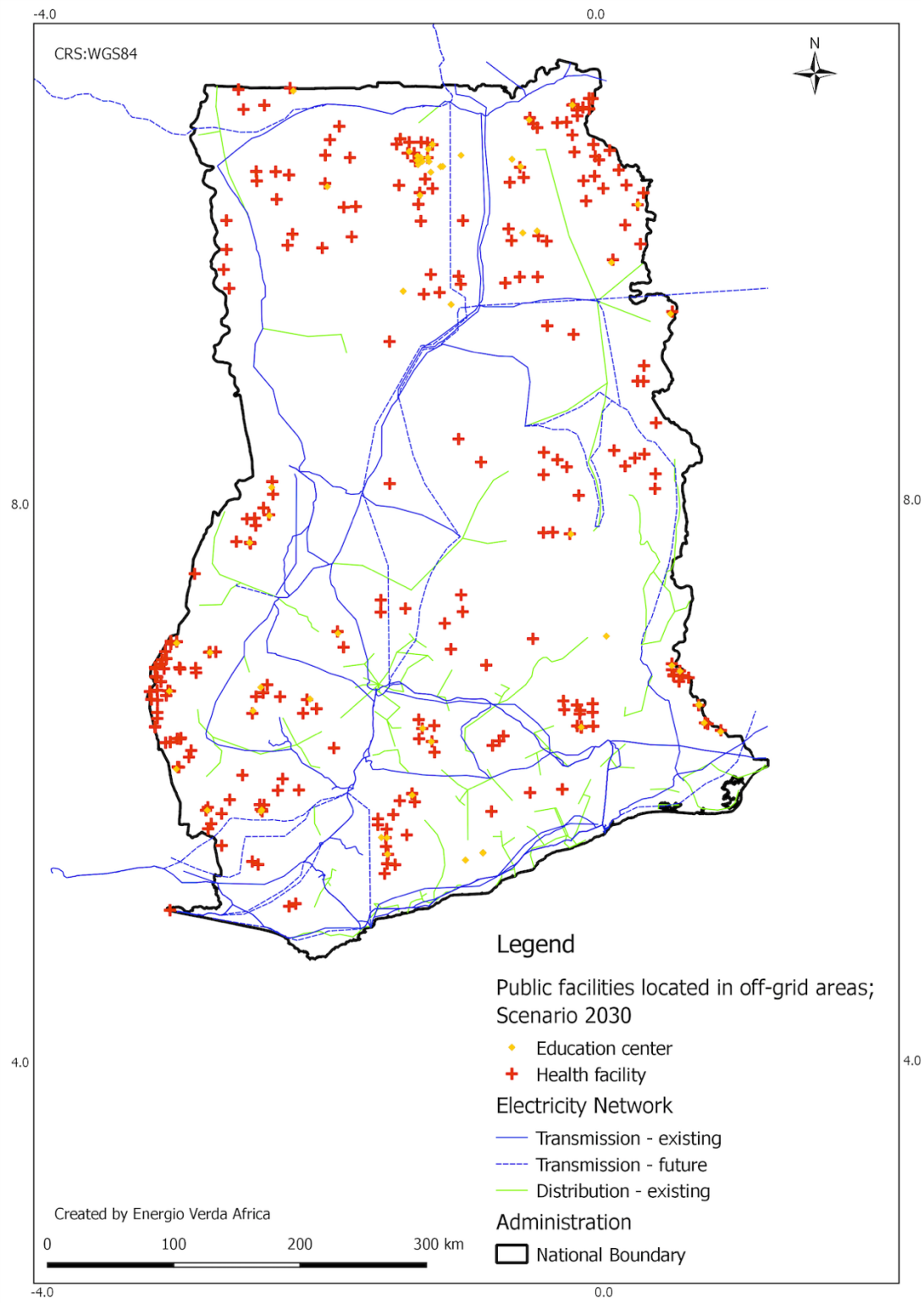
Figure 9: Distribution of Potential Off-Grid Social Facilities, 2023[72]



Source: Energio Verda Africa GIS analysis

[72] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

Figure 10: Distribution of Potential Off-Grid Social Facilities, 2030[73]



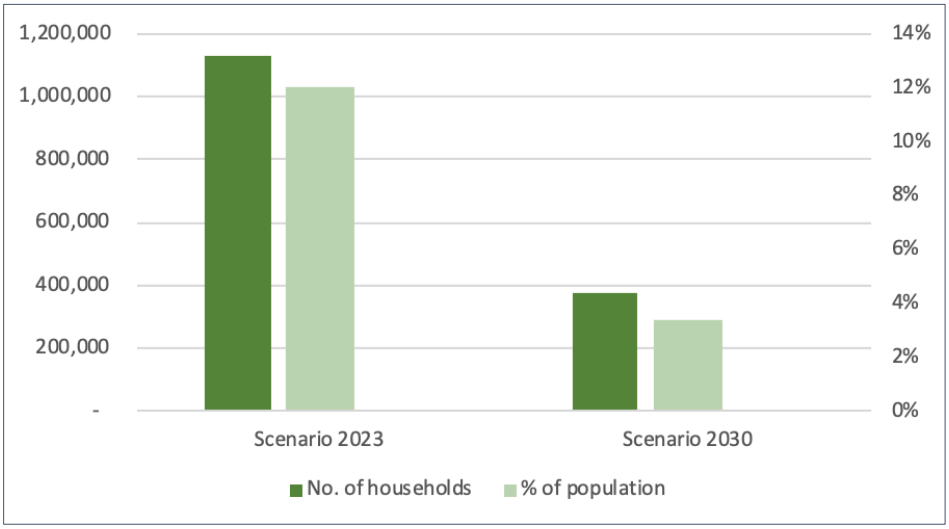
Source: Energio Verda Africa GIS analysis

[73] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

According to the geospatial analysis (**Table 5**), by 2023, 8,373 settlements across Ghana (5,948,889 households) will be connected to the main grid, representing 63.6% of the population. By 2030, this figure will increase to 18,384 settlements (9,663,851 households), equivalent to 88.7% of the population. These estimates are based on the assumption that all planned grid extensions will be completed by 2030. Not all settlements in close proximity to electricity lines will connect to the main grid, largely due to the low density of these areas (dispersed settlements with a density below 350 people/km^2). By 2023, an estimated 1,399 settlements located under the grid will meet these criteria (or 14.3% of the settlements located within 5 km of the grid).

Outside of the main grid areas, settlements with higher economic growth potential and higher population density can optimally be electrified by mini-grids. By 2023, this represents an estimated 10,063 settlements (2,280,057 households), or 24.4% of the population, decreasing to 3,329 settlements (859,009 households), or 7.9% of the population by 2030. The remaining more dispersed settlements (further from centers of economic activity) can optimally be served by off-grid stand-alone systems. This comprises 4,874 settlements (1,127,303 households) and 12.0% of the population in 2023, decreasing to 1,597 settlements (372,913 households) and 3.4% of the population in 2030 (**Figure 11**).

Figure 11: Estimated Number of Households and Share of Population Suitable for OGS Systems, 2023 and 2030



Source: Energio Verda Africa GIS analysis

In its SEforALL National Renewable Energy Action Plan, the GoG anticipated that about 8% of the country's population would gain electricity access through off-grid systems (**Table 6**). While plans for expansion of distribution lines were not available, the results of the analysis (**Table 5**) show that by 2023 about one-third of the population will still be living outside of a 5 km radius of national grid lines and many people (especially in rural areas) will not be able to afford GHS 2,400 (USD 450) for a grid connection. The results of the least-cost analysis therefore suggest that the Government may need to consider increasing the utilization of off-grid solutions (mini-grids and stand-alone systems) in its electrification planning in order to achieve its energy access targets.

Table 6: Estimated Share of Population Served by Off-Grid Systems[74]

Electricity Access Targets	2020
Share of population connected to the grid (%)	92%
Share of population with access to off-grid systems powered by renewable energy (%) *	8%

* Estimate includes both mini-grids and stand-alone systems

Source: SEforALL National Renewable Energy Action Plan

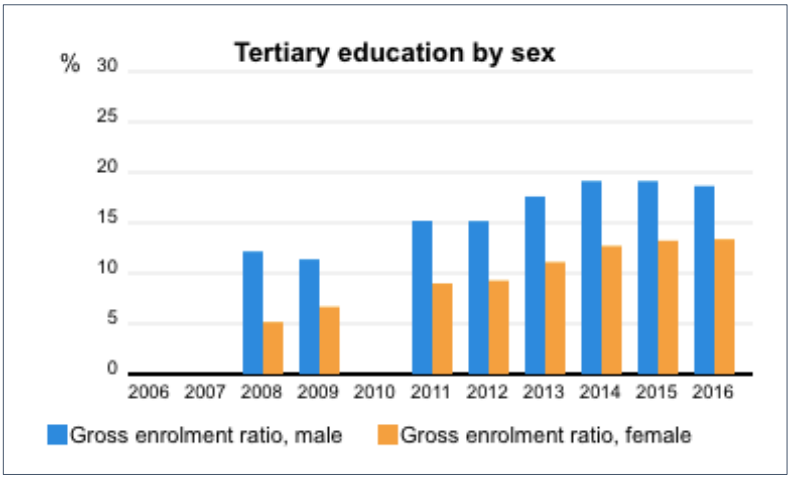
The stand-alone solar market in Ghana has the potential to grow significantly. According to figures published by the Global Off-Grid Lighting Association (GOGLA), an estimated 114,658 of off-grid stand-alone solar PV products (pico solar and SHS) worth over USD 3 million have been sold in Ghana through the end of 2017 (see **Section 2.4.3**).[75] The least-cost analysis estimates that, about 12% of the population and over 1.1 million households will be suitable for these solutions in 2023.

1.2.2.5 Inclusive Participation[76]

Inclusive participation in Ghana remains an ongoing challenge. Gender inequality persists, as women are under-educated and generally have a lower socio-economic status, with inadequate access to basic social services and reduced economic opportunities compared to men. Ghana performs poorly in the UNDP Gender Inequality Index, which measures several indicators to assess levels of gender inequality in the areas of health, access to education, economic status and empowerment.[77] Female participation in education, particularly higher education, remains disproportionately low (**Figure 12**).[78] While gender discrimination is widespread, these issues tend to be more pronounced in rural areas of the country.

[74] "Ghana National Renewable Energy Action Plan," ECREEE / SEforALL, (2015):
[75] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf
[76] See **Annex 4** for more details
[77] "Gender Inequality Index," UNDP, (2015): http://hdr.undp.org/en/composite/GII
[78] "Ghana Participation in Education," UNESCO Institute for Statistics, (2018): http://uis.unesco.org/en/country/bf?theme=education-and-literacy

Figure 12: Rates of Enrollment in Tertiary Education



Source: UNESCO Institute for Statistics

Ghana has adopted several policies and action plans to promote gender equality and has signed on to key international and regional framework agreements protecting women's rights. The Ministry of Gender, Children and Social Protection is responsible for implementing all national gender policies and promoting inclusive participation for women in the public and private sectors. The country's guiding policy framework is the National Gender and Children's Policy (2004), which focuses on mainstreaming gender equality, the empowerment and social protection of women, emphasizing equal access for women to productive resources such as land, labor, technology, capital/finance, and information.

In the energy sector, efforts have been made to implement measures under the regional framework, ECOWAS Policy for Gender Mainstreaming in Energy Access, as well as of the national level. The Government's Policy Commitment on Women Empowerment and Livelihoods seeks to accelerate efforts specifically targeting the promotion and awareness raising of sustainable energy applications for women to inform decisions at the household level. Gender mainstreaming in the country's energy policy requires capacity building of staff and the implementation of gender management systems at the institutional level to provide guidance on gender responsive leadership and decision making. As part of this process, the Government has established a gender focal point to promote inclusive participation for women and has also conducted a Gender Audit of the sector.

Ghana has also made progress towards equalizing energy access through the launch of its Social and Gender Integration Plan. Ghana's Millennium Development Authority will oversee implementation of the action plan, which aims to ensure greater energy equality by addressing social inequalities among men, women and vulnerable groups of citizens, such as the elderly, socially excluded and disabled.[79]

[79] "A step towards energy-access equality in Ghana," Energia, (2017): http://www.energia.org/step-towards-energy-access-equality-ghana/

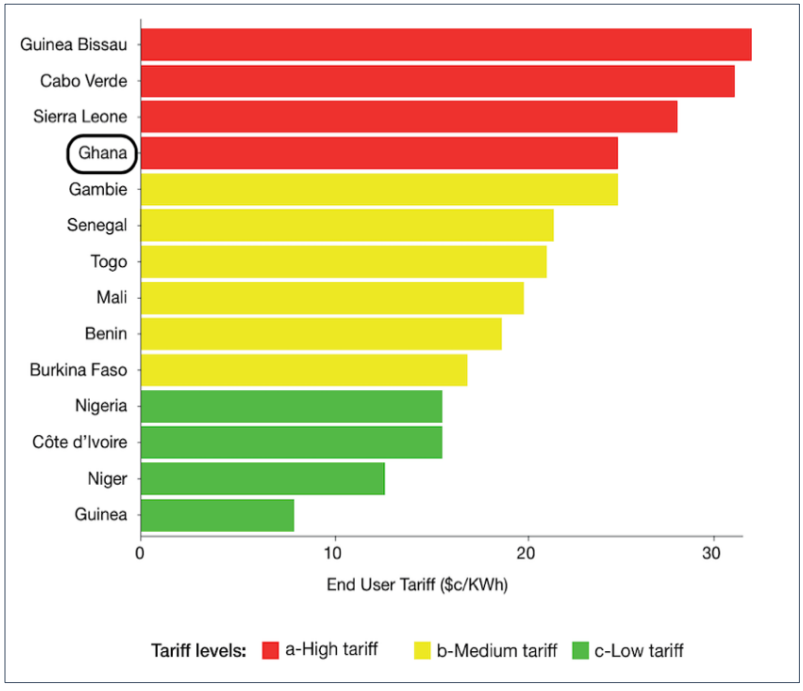
1.2.3 Key Challenges

Some of the key energy sector challenges facing Ghana include (but are not limited to) the following:

- **Investment in Grid Extension and Maintenance:** Economic growth and corresponding increases in electricity demand are putting pressure on power supply – a mismatch that will continue to burden the electricity transmission and distribution network that needs maintenance and investment to reduce losses and expand access.

- **Electricity Tariffs:** Average electricity tariffs in Ghana ($0.25/kWh) remain relatively high compared to other countries in the region (**Figure 13**). Ghana subsidizes electricity tariffs for low-income consumers, providing electricity to poorer households below the cost of supply with funds from the GoG and the utility (ECG) through a range of residential and commercial consumers who pay higher electricity rates. While this subsidization scheme has made power affordable for most residential consumers (particularly low-income households), commercial users/SMEs pay one of the highest electricity tariffs in the region at $0.34/kWh – approximately 77% higher than residential tariffs (**Figure 14**).[80] In 2018, the PURC conducted a review of the tariff and announced a reduction in rates, with the largest percentage reduction for non-residential users.[81]

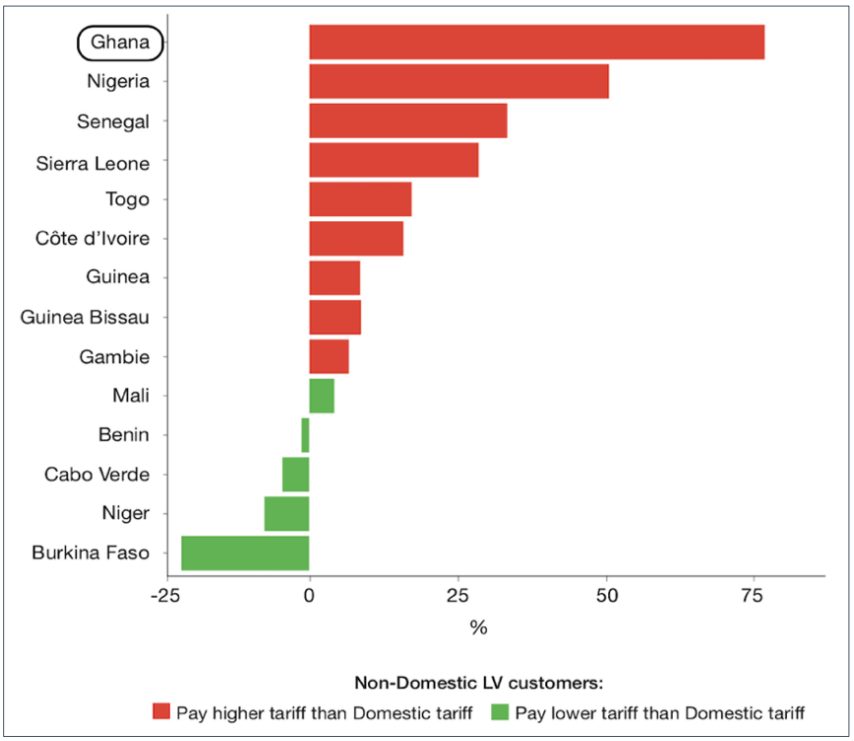
Figure 13: Average End-User Tariffs in ECOWAS Countries, 2018



Source: ECOWAS Regional Electricity Regulatory Authority

[80] "Electricity Tariffs in ECOWAS Region," African Development Bank Group, Energy Policy, Regulation and Statistics Division, (September 2018): http://www.ecowrex.org/sites/default/files/pesr1_-_energy_statistics_bulletin_september_2018.pdf
[81] "2018 Electricity Major Tariff Review Decision," Public Utilities Regulatory Commission (PURC), Ghana, (June 2018): http://purc.com.gh/purc/sites/default/files/final_tariff_decision_2018_0.pdf

Figure 14: Commercial Tariff in Excess of Residential Tariff in ECOWAS Countries, 2018



NOTE: Liberia is excluded from the analysis; the disparity in electricity tariffs between commercial and residential consumers is an indication of the existence of a subsidization or cross-subsidization scheme that typically favors low-income residential consumers.

Source: ECOWAS Regional Electricity Regulatory Authority

- **Utility Financial Performance:** Without cost-reflective tariffs in place, ECG is not financially viable. As a result, Ghana's power sector remains largely dependent upon foreign assistance, while the overall quality of electricity service is in need of improvement. A related issue is the relatively weak state of the local currency and the associated currency risk (PPAs are paid in USD, while electricity is sold at fixed rates in Ghanaian cedi). These challenges, among others, have limited the utility's revenue, hampering its ability to invest in the country's power infrastructure.[82]

- **Imbalanced Energy Mix**: The country's power sector is overly reliant upon fossil fuels and large hydropower, technologies that are susceptible to price volatility and climatic conditions, respectively. The GoG appears to be shifting a significant portion of its installed capacity to renewable energy (**Table 4**), although the majority of this will still come from large hydropower.

- **Rural Electrification:** Although electrification rates are relatively high in Ghana, a gap in the rates of access still exists between rural and urban areas. While thousands of Ghanaian communities have been connected to the grid through the NES and SHEP programs, the GoG still faces significant rural electrification challenges related to high costs for grid extension to isolated areas, inadequate funding

[82] Kumi, E. N., "The Electricity Situation in Ghana: Challenges and Opportunities," Center for Global Development, (September 2017): https://www.cgdev.org/sites/default/files/electricity-situation-ghana-challenges-and-opportunities.pdf

(particularly in the form of working capital for local suppliers and distributors), the absence of private capital and lack of O&M capacity for renewable systems especially mini-grids, among others.[83]

- **Local Financial Institutions:**[84] Local financial institutions (FIs) and microfinance institutions (MFIs) lack sufficient internal capacity and credit appetite to invest in the renewable energy/off-grid sectors. This challenge is complicated as it arises mainly from the risk perceptions of FIs, which influence whether efforts should be made to develop strategies and customize financial products to target a nascent market, where there is often limited knowledge of technologies, market characteristics and historical data on portfolio credit performance. There are also likely misperceptions about the potential size of these markets as well as doubts about the profitability of offering financial products in rural off-grid areas, where the creditworthiness of potential clients may be an issue. The renewable energy/off-grid space is particularly complicated given relatively high transaction costs and a comparatively unfavorable regulatory environment that exists in the country.[85]

- **Other Challenges**: Successful development of the off-grid sector will require more than just a financial support mechanism – the Government and its supporting agencies will also need to develop and implement a range of measures to expedite growth of the market, including a robust technical assistance (TA) platform to supplement ROGEP's objectives. This platform should address *inter alia* (i) awareness raising, education and training for consumers, including organization of appropriate community management structures; (ii) solar PV system supply chain and operations and maintenance (O&M) services, including training of local technicians to ensure that the cost of maintenance is affordable and sustainable; and (iii) standards for equipment and service providers (i.e. installers, technicians) to guide customers to companies providing the best value for their money. These measures should be part of a national rural electrification sector strategy to inform decision-making of key stakeholders surrounding development and regulation of the country's stand-alone solar PV market.

[83] "Universal Access to Energy: Ghana's Rural Electrification – A Case Study," Ministry of Energy & Petroleum Ghana, (2013): https://www.engerati.com/sites/default/files/13h30%20Barfour%20Tues%20T%26DSmart.pdf

[84] The role of FIs is examined in further detail in **Section 3**.

[85] One notable exception to this is the commercial and industrial (C&I) market segment, where systems are larger and off-takers are often companies with large enough balance sheets to borrow. This has been one of the stand-alone market segments where there has been some lending to date in Africa (e.g. AFD's Sunref program).

1.3 National Policy and Regulation

1.3.1 National Electricity/Electrification Policy

Following the implementation of the power sector's restructuring and reform in the 1990s, the Ministry of Energy and the Energy Commission have adopted and initiated several plans to promote national electrification. In the 2006-2020 Strategic National Energy (SNEP) Plan, the GoG prioritized the incorporation of off-grid systems, and particularly solar systems distributed to small off-grid communities of less than 1,000 inhabitants and communal facilities such as schools and health centers. In 2010, Ghana adopted the National Energy Policy to encourage the use of decentralized off-grid alternatives technologies including solar PV. These policies aimed to build upon the NES, which had a long-term objective of extending reliable electricity supply to all communities over a 30-year period from 1990-2020, and included several operational programs/plans to reach its targets:

- The Self-Help Electrification Program (SHEP) encouraged communal participation and the self-help developmental initiatives of communities within 20 km of the existing distribution network
- The National Decentralized Electricity Program aimed at providing electricity access to remote off-grid and island communities, providing financial support to initial PV products investments
- The Solar Lanterns Promotion Program: 80,000 solar lanterns procured through GoG between 2013-2015, of which 50, 000 sold at 70% subsidy to end-consumers.

Ghana's Shared Growth and Development Agenda, 2014-2017 (GSGDA) set the basis for the country's electrification strategy and policy.[86] In 2015, the GoG adopted the National Renewable Energy Action Plan, developed in partnership with ECREEE, for the period of 2015–2020. This plan bolstered the Government's strategy to support the use of off-grid systems for remote areas, including a large-scale effort to distribute solar lanterns – the GoG target is to distribute 500,000 units by 2020 and 2 million by 2030 (against 70,000 units in 2015). In 2019, the REMP established a range of targets for the country to achieve universal electrification and includes plans to add a total of 20 MW of stand-alone solar capacity by 2030.[87]

The Government has also made ambitious commitments to meet its Nationally Determined Contributions (NDCs) following the United Nations Framework Convention on Climate Change (UNFCCC) Paris Climate summit. These targets include:[88]

- Increasing renewable energy penetration to 10% by 2030 by introducing 55 solar mini-grids with an average capacity of 100 kW (10 MW) and scaling up the 200,000 solar home systems for lighting in urban and selected non-electrified rural households
- Promoting clean rural households' lighting by increasing solar lantern replacement in rural non-electrified households

To meet its renewable energy and energy access objectives, the Government aims to boost private sector participation in the sector. Under the mandate of the Renewable Energy Act, the GoG plans to establish a Renewable Energy Authority (REA) and accelerate operationalization of a Renewable Energy Fund (REF). The REF will provide financial resources to promote development, sustainable management and utilization of renewable energy sources. The fund intends to create financial incentives, feed-in-tariffs, capital

[86] Ghana Shared Growth and Development Agenda (2014-2017): http://www.un-page.org/files/public/gsgda.pdf
[87] Ghana Renewable Energy Master Plan: https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/UNDP_GH_SUS_DEV_REN_MASTER_PLAN_2019.pdf
[88] "Energy Profile Ghana," UNEP, (2015): http://wedocs.unep.org/bitstream/handle/20.500.11822/20509/Energy_profile_Ghana.pdf?sequence=1&isAllowed=y

subsidies, production-based subsidies and equity participation for mini-grid and off-grid renewable power systems for remote areas and island operation.

1.3.2 Integrated National Electrification Plan

The above-mentioned NES and subsequently the REMP provide a coherent and integrated framework for Ghana to achieve universal electrification by 2030.

1.3.3 Energy and Electricity Law

The electricity sector in Ghana is organized by the Energy Commission Act (Act 541) of 1997, which establishes the Energy Commission as well as its functions to manage the development and utilization of energy resources in Ghana. The Act also includes provisions for licensing the transmission, generation, distribution and sale of electricity in the country. It should be noted that Ghana is one of the few countries in the ECOWAS region that has effectively enacted the Renewable Energy Act (No.832, 2011). This Act is the basis for the development, management, utilization, sustainability, and adequate supply of RE for generation of electricity.[89] The Renewable Energy Act is the foundation of the Grid Code for utility-scale RE grid interconnection, the net-metering Code, the guidelines on RE purchase obligations, the licensing framework, the feed-in-tariff scheme, and the competitive bidding for solar.

With regards to off-grid provisions, the RE Act highlights the importance of mini-grids and stand-alone systems for the electrification of remote off-grid locations. Under this act, Ghana has implemented a variety of national strategies which include: (i) the Ghana Energy Development and Access Project, (ii) the Scaling-up Renewable Energy Program (SREP), and (iii) technical support for the implementation of the Renewable Energy Act.[90] Although an off-grid policy was under consideration, it has not been adopted yet.

1.3.4 Framework for Stand-alone Systems

Figure 15 is an overview of the key national policies, programs, laws and regulations pertaining to Ghana's framework for stand-alone systems. The gaps in this framework are addressed in **Section 1.3.5**.

To date, the Government's efforts to establish a supportive policy and regulatory framework for the off-grid sector are progressing well, as evidenced by the country's 4-point improvement in its World Bank Regulatory Indicators for Sustainable Energy (RISE) energy access score between 2015 and 2017. In the 2017 RISE evaluation, Ghana ranked second behind only Cameroon in West Africa and the Sahel and was among the highest scoring countries in Africa (**Figure 16**).[91]

[89] "Renewable Energy Act," The Parliament of the Republic of Ghana, (2011): http://energycom.gov.gh/files/RENEWABLE%20ENERGY%20ACT%202011%20(ACT%20832).pdf

[90] "Renewable Energy Policy Review, Identification of Gaps and Solutions in Ghana," Energy Commission, UNDP, (December 2015): http://energycom.gov.gh/files/Renewable%20Energy%20Policy%20and%20Regulatory%20Gap%20%20%20%20%20Analysis%20Final(2015).pdf

[91] "Policy Matters: Regulatory Indicators for Sustainable Energy," World Bank ESMAP, (2018): http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf

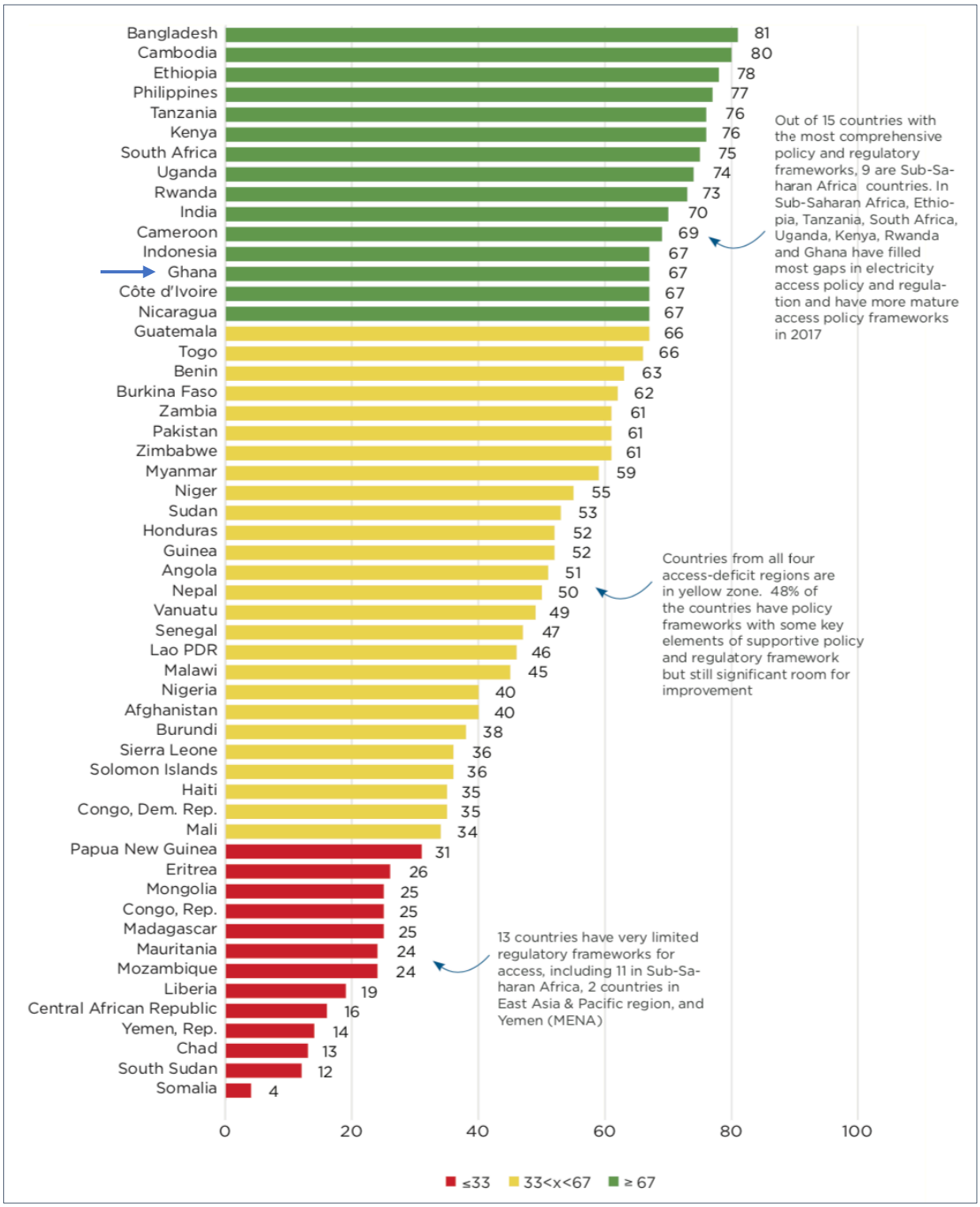
Figure 15: Policy and Regulatory Framework for Stand-alone Systems

GHANA			
	World Bank RISE 2017 Energy Access Score: 67 World Bank RISE 2015 Energy Access Score: 63	2017 ranking among West Africa and the Sahel (ROGEP) countries: 2nd	
Policy/Regulatory Support and Financial Incentives	**Specific national policies, laws and programs**		
	National electrification policy with off-grid provisions	√	NES, GSGDA, SNEP
	Integrated national electrification plan	√	NES, REMP
	Energy/electricity law with off-grid provisions	√	Renewable Energy Act 2011
	National programs promoting off-grid market development	√	SHEP, SREP, SLAP
	Specific target for rural electrification	√	Universal access by 2030
	Financial incentives		
	Subsidies, tax exemptions or related incentives for solar equipment/stand-alone systems	√	Import duty / VAT exemptions; REF
	Standards and quality		
	Government-adopted international quality standards for stand-alone systems	√	Ghana Standard Authority
	Government-certified program for solar equipment installers	√	Ghana Association of Solar Industries
	Consumer awareness/education programs		
	Concession Contracts and Schemes	x	
	Business Model Regulation	x	

√ = existing/implemented provisions in the current regulatory framework
X = no existing provisions

Source: World Bank RISE, Stakeholder interviews and GreenMax Capital Advisors analysis

Figure 16: Distribution of RISE Electricity Access Score in Access-Deficit Countries, 2017[92]



Source: World Bank Regulatory Indicators for Sustainable Energy

[92] "Policy Matters: Regulatory Indicators for Sustainable Energy," World Bank ESMAP, (2018): http://documents.worldbank.org/curated/en/553071544206394642/pdf/132782-replacement-PUBLIC-RiseReport-HighRes.pdf

1.3.4.1 Existence of Specific National Programs

In addition to the NES and SHEP described above, several additional national programs targeting development of the country's renewable energy and off-grid sectors have been implemented.

In 2014, Ghana was one of 14 pilot countries selected to benefit from the SREP program, funded by the Climate Investment Funds (CIF) and other Multilateral Development Bank including the AfDB, IFC, WB and other development partners. One of the four key projects of Ghana's SREP Program is focused on four key projects: (i) renewable energy mini-grids and stand-alone solar PV systems; (ii) solar PV-based net metering with storage; (iii) utility-scale solar PV/wind power generation; and (iv) technical assistance to scale-up renewable energy. Out of the USD 1.51 million awarded to Ghana under SREP, USD 899,800 is dedicated to renewable mini-grids and stand-alone solar systems. The program includes the following provisions for stand-alone solar:[93]

- Installation of 20,500 stand-alone systems to meet desirable loads for households to serve an estimated 106,600 people using a partial subsidy and credit facility under the private sector-led initiative
- Installation of 1,350 stand-alone systems for schools to serve some 243,000 students
- Installation of 500 stand-alone systems for health centers and 400 stand-alone systems for communities to service an estimated 215,000 people
- Review of the proposed models to restructure the financing scheme of the stand-alone component
- Zoning and prioritizing communities for effective and efficient delivery

Another initiative, the Solar Lantern Promotion Programme (SLAP), managed by the Energy Commission, aims to distribute two million solar lanterns in remote off-grid communities by 2020 – 8,000 of these lanterns have already been procured and over 50,000 sold with a 50% subsidy since 2013.[94]

In addition to Government-funded initiatives, several community-driven stand-alone solar projects have also achieved success, most notably the Weichau project, ISOFOTON project and the ARB Apex Bank project. All three of these projects provided lighting solutions and other services until grid extension reached the communities. All these projects were based on the fee-for-service model and community ownership was key to their success.

The Weichau Project**,** initiated in 1997, provided a battery bank where community members could go to recharge solar batteries. In addition to household and school lighting, the project provided portable water to the community and refrigeration for vaccines in the clinic. The ISOFOTON project, funded by the Spanish government's Renewable Energy Services Project (RESPRO), provided individual panels to interested households under a fee-for-service subsidized scheme. The ARB Apex Bank Project, financed by GEF, supported the formation of the Association of Ghana Solar Industries to enhance the participation of private sector in providing maintenance and system supply. Under this project, the ARB Apex Bank provided low-interest loans to rural communities to obtain solar systems and lanterns, while the Government supported beneficiaries with a 50% grant subsidy. The program helped install 15,000 stand-alone systems for 90,000 rural people.[95]

[93] "SREP Investment Plan for Ghana," Climate Investment Funds, (May 2015): https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/srep_ip_presentation_ghana_may13_2015_0.pdf
[94] "National renewable Energy Action Plans (NREAPs) of Ghana," SE4All / ECREEE, (2015): http://www.se4all.ecreee.org/sites/default/files/ll.ghana_nreap_vs_final.pdf
[95] Ghana Renewable Energy Master Plan: https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/UNDP_GH_SUS_DEV_REN_MASTER_PLAN_2019.pdf

1.3.4.2 Financial Incentives

The Government's tax exemption regime for renewable energy technologies includes import duty exemptions for solar PV equipment. Additionally, all off-grid solar system components – including solar panels, batteries, and inverters – irrespective of system size, benefit from exemption on VAT. This exemption does not apply if the components are imported separately. The Ghana Investment Promotion Council Act 2013 (Act 865) also includes tax incentives for investments in the sector. When operational, the REF will provide additional support for off-grid development, including mechanisms to reduce the upfront cash cost of solar lighting equipment for consumers and improve the business environment for entrepreneurs to develop small solar energy businesses.

1.3.4.3 Standards and Quality

Ghana has its own Mandatory Appliance Standards and Labelling regimen under which importers and retailers of solar lamps are required to import only if the products meet minimum efficiency and performance standards approved by the Ghana Standard's Authority. In particular for the off-grid sector, the Ghana Standards Authority lists several international standards for solar devices and products (e.g. IEC-compliant). Additionally, the Ghana Association of Solar Industries has introduced a certification system for solar equipment and service providers.

The GoG also supports a variety of policy support schemes to promote the use of energy from renewable resources in electricity generation. Some of these include regulatory schemes that set mechanisms to achieve targets, financial support for investments and soft measures that provide information, education or awareness creation. A major step the Government has taken in this regard is the is the establishment of a National Energy Information Center at the Energy Commission to disseminate available information on all energy-related matters to the public, researchers and other stakeholders. Moreover, the Government plans to establish an energy information database to provide relevant market information to interested parties to foster an inclusive process in the implementation of policies. The National Energy Policy also stresses the necessity to support a sustained and comprehensive public education and awareness creation campaign on the methods and benefits of energy conservation measures.

1.3.4.4 Concession Contracts and Schemes

Although there are no concession contracts and schemes for the off-grid sector currently in effect, a concession agreement framework between the GoG and private stakeholders does exist in the country. Under its mandate, the EC is authorized to delineate a specific geographic zone or area to be covered by a distribution license and to grant the licensee the exclusive rights to the given zone or area. This will apply by extension to mini-grids. Under a concession, there is no requirement for government ownership of assets although traditionally the assets have been government-owned. There is currently at least one investor owned distribution entity (Enclave Power Company) that procured and installed, owns and operates the network under license issued by the EC.[96]

To date, the GoG has been very successful at extending the reach of the national grid into rural areas. This has largely been achieved due to significant capital subsidies. A similar scheme will need to be implemented to support off-grid development; subsidies can target either consumers or producers and can be either recurrent or for capital expenses (more 'one-off' expenses). The Government will also need to design a

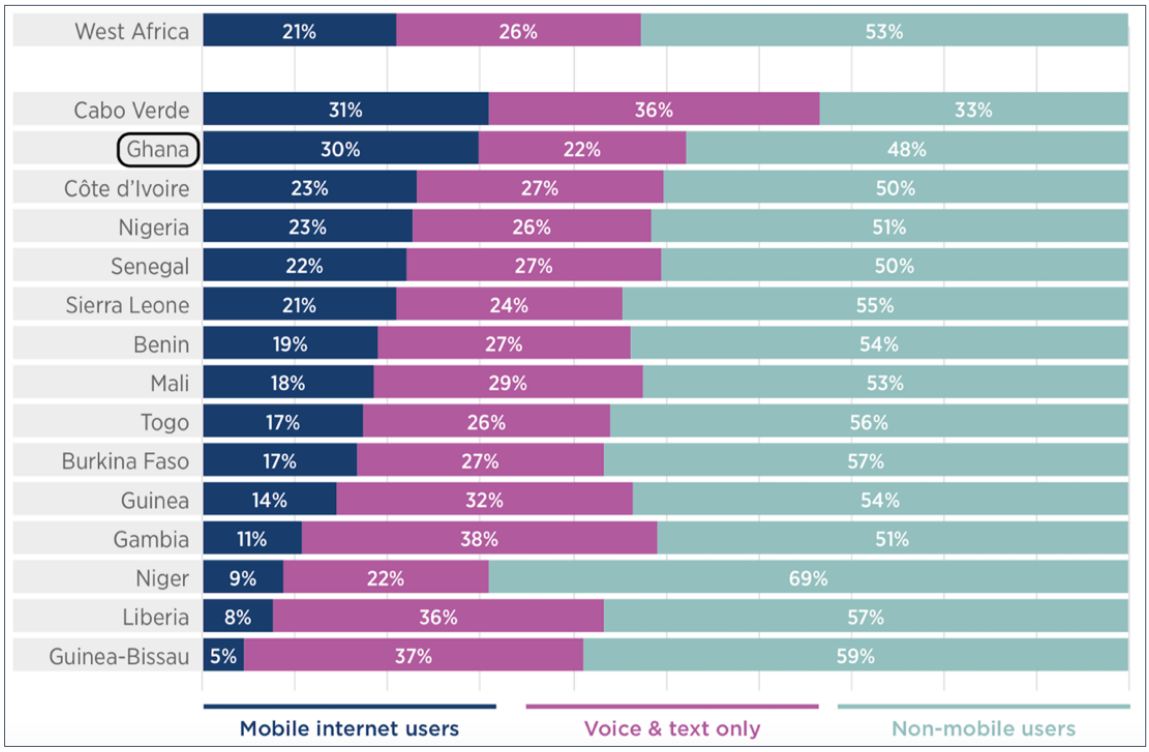
[96] "Ghana: Mini-Grids for Last-Mile Electrification," ESMAP, (2017): http://www.eca-uk.com/wp-content/uploads/2017/08/ESMAP-Ghana_Mini_grids_for_last_Mile_Electrification_Optimized.pdf

well-structured competitive procurement process in order to successfully engage the private sector in development of the sector.

1.3.4.5 Specific Business Model Regulation

No specific business model regulations exist for the off-grid sector in Ghana, although the Government can take measures to support PAYG business models that have already been deployed by private solar companies engaged in the market. As was demonstrated in East Africa in recent years, the proliferation of mobile money platforms can rapidly facilitate energy access. Recent data suggests that there is an opportunity for the GoG to bring together key stakeholders in the off-grid sector (solar providers, telecommunications companies etc.) to take advantage of the country's growing mobile internet usage (**Figure 17**) and high rates of mobile phone ownership in rural areas (**Figure 18**). Moreover, a transition to mobile broadband networks is gaining rapid momentum, with Ghana among the five largest markets in West Africa in terms of size and share of subscriber growth.[97]

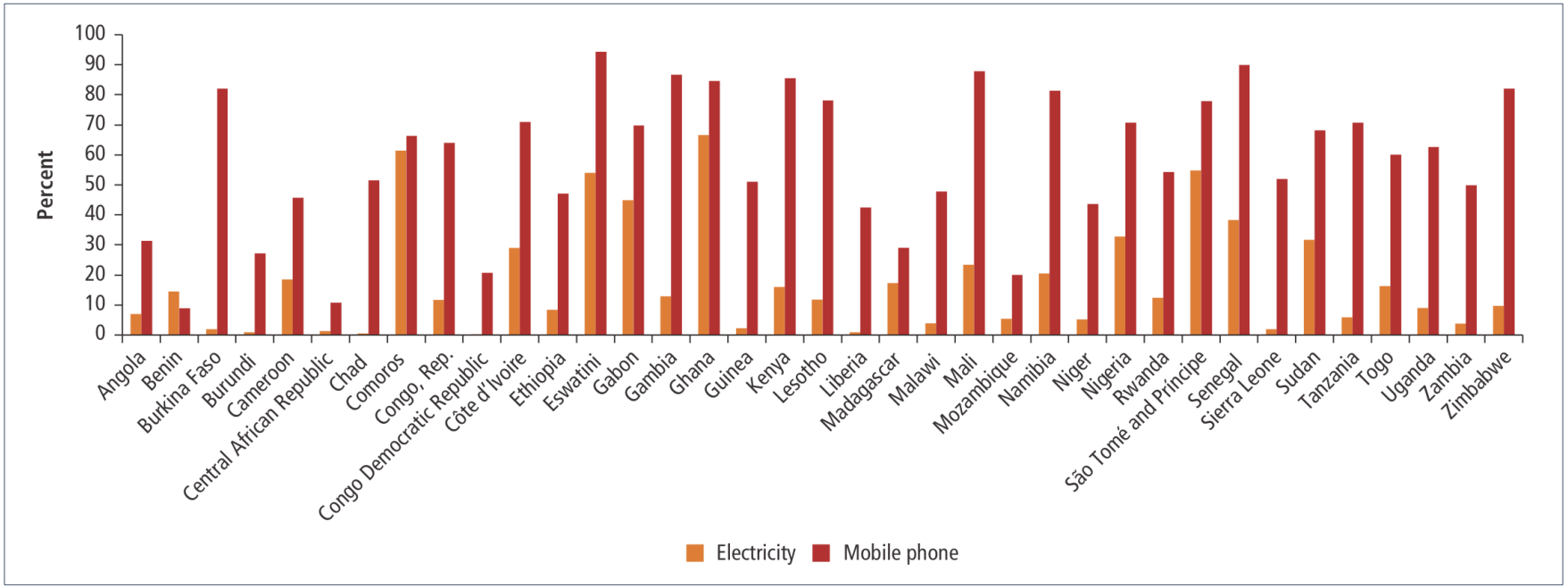
Figure 17: West Africa Mobile Internet Penetration Rates, 2017[98]



Source: GSMA Intelligence

[97] "The Mobile Economy: West Africa 2018," GSMA Intelligence, (2018): https://www.gsmaintelligence.com/research/?file=e568fe9e710ec776d82c04e9f6760adb&download
[98] GSMA: The Mobile Economy – West Africa, 2018.

Figure 18: Electricity Access and Mobile Phone Ownership in Sub-Saharan Africa, 2016 (% of rural households)[99]



Source: World Bank

[99] Blimpo, M., and Cosgrove-Davies, M., "Electricity Access in Sub-Saharan Africa: Uptake Reliability and Complementary Factors for Economic Impact," AFD and World Bank, (2019): https://openknowledge.worldbank.org/bitstream/handle/10986/31333/9781464813610.pdf?sequence=6&isAllowed=y

1.3.5 Capacity Building and Technical Assistance

To overcome the challenges surrounding rural electrification, a range of technical and financial resources from both the public and private sector must come together. At the institutional level, the MoE, EC and the electricity market regulator, PURC, among others, will play key roles in establishing a supportive policy and regulatory framework. Additional reforms to the power sector may be required to provide the incentives necessary to increase private sector participation. Local FIs and MFIs will need incentives and support to develop and implement new financial products and administrative procedures to lend to the off-grid sector. International and local solar companies will need policy and financial support. Local technical capacity of the solar sector will need to be developed to ensure long-term O&M services are available and sustainable. Above all, financing and TA will be critical for all market actors – government, financial institutions, end-users, suppliers and service providers – in order to accelerate growth.

In general, Ghana has a robust set of policies, incentives, procedures, standards and supporting mechanisms in place, evidenced by its relatively high rates of electrification compared to other countries in the region. **Table 7** identifies some of the policy/regulatory gaps and corresponding TA interventions for Ghana as aims to meet its goal of universal access by 2020.

Table 7: Gaps in the Off-Grid Policy and Regulatory Framework[100]

Indicator	Policy/Regulatory/Market Gaps	Recommended TA Intervention
1. **Specific National Policies, Laws and Programs**	A. **Government is Subsidizing Fossil Fuel Power Generation**	a. Help Government analyze where fossil fuel subsidies serve as an impediment to development of safe, clean energy access alternatives
	B. **Insufficient Energy and Electricity Law** a. No specific Energy or Electricity Law with off-grid provisions exists	a. Help Government revise legal framework (Renewable Energy Act 2011) to ensure that it is flexible and helps create appropriate incentives for private sector participation in off-grid market development (e.g. to continue process of restructuring and unbundling the electricity market)
2. **Financial Incentives (import duties, taxes, etc.)**	A. **Insufficiently supportive financial incentives / tax regime**	a. Help Government expand existing financial incentives[101] to cover the entire off-grid stand-alone solar product supply chain, including batteries, inverters or other system components to provide necessary support to the industry b. Help Government establish a Special Task Force to (i) mitigate potential difficulties in customs clearance and import logistics, and (ii) oversee implementation of tax exemptions by coordinating with all agencies and regulatory bodies involved – Energy Commission, Customs Authorities, Ghana Revenue Authority, Ghana Standard's Authority etc.

[100] NOTE: "Government" as it is used throughout this table refers to the main public institutions, officials and policymakers responsible for planning, management and regulation of the energy sector in Ghana (**Table 2**), including the Ministry of Energy (MoE), Energy Commission (EC), Public Utilities Regulatory Commission (PURC), Volta River Authority, and the Electricity Company of Ghana (EC) among other national and local authorities

[101] The GoG has implemented an import duty and VAT exemptions for solar equipment

		c. Help Government introduce appropriate grant and subsidy schemes which require private funding matches and are predictable and not overly bureaucratic (e.g. through the planned Renewable Energy Fund, REF) d. Help Government create PPP schemes to share high project development and market entry costs particularly with developers in remote areas (e.g. through the planned REF) e. Help Government analyze where subsidies or exemptions for non-renewable energy sources provide unfair advantage for fossil-fuels and impede development of clean energy solutions
3. **Standards and Quality**	**A. Insufficient Market Data**	a. Help Government establish a Special Task Force (e.g. through the MoE or Energy Commission) responsible for collaborating with the private sector to compile and regularly update a database of critical off-grid market data (including inter alia solar product imports, costs, sales volumes, resource potential etc., GIS data and other key demographic and socioeconomic indicators) that can be (i) utilized by policymakers to make informed electrification planning decisions based on accurate/updated market information, and (ii) made easily accessible to interested off-grid developers, investors and other key industry stakeholders
	B. Inadequate capacity of local technical sector (solar PV technicians, installers, services providers etc.)	a. Support establishment of technical certification and vocational training programs through government, private sector, and/or academia for installation and maintenance of stand-alone solar systems (e.g. through the Ghana Association of Solar Industries) b. Support development of database of best practices / information sharing services to ensure skills transfer from international, local and regional initiatives (e.g. through the Ghana Association of Solar Industries)
	C. Insufficient attention of private companies to environmental/social standards and community engagement	a. Assist private sector and/or civil society organizations to ensure environmental/social standards are in place b. Assist in development of strategies encouraging inclusive gender participation c. Support with the implementation of a repair and recycling framework for off-grid solar systems and equipment

	D. Insufficient public awareness	a. Support Government, trade associations and civic society organizations to develop and implement consumer awareness, marketing and education programs on the benefits of off-grid solar products and the existence of related national programs[102] b. Support development and implementation of programs to educate consumers, retailers and distributors on the benefits of quality certified solar products vs. counterfeit products (e.g. through the Ghana Association of Solar Industries)
4. Concession Contracts and Schemes	**A. Lack of clear and transparent licensing and permitting procedures** a. Unclear procedures b. Insufficient communication and streamlining	a. Help Government develop clear licensing and permitting procedures b. Help Government develop improved systems for sharing and disseminating information to project developers and key stakeholders, including establishment of a "one-stop-shop" for national and local level permits and approvals
	B. Lack of understanding of emerging concession and energy services schemes for off-grid providers a. Need for understanding of different SHS concession schemes b. Need for understanding of emerging models for 'Integrated Private Utilities' or 'Energy Companies of the Future' c. Public procurement or public finance/budget laws that hamper deployment of energy services models for public facilities	a. Help Government understand all options and models for possibilities of granting geographic concessions to private operators of SHS[103] b. Help Government to understand and develop approaches to facilitate pilots of 'Integrated Private Utility' or 'Energy Company of the Future' schemes.[104] c. Help Government develop procurement and public finance laws that will facilitate stand-alone solar system investment for public facilities (schools, healthcare facilities, etc.)

[102] The National Energy Policy stresses the importance of a sustained and comprehensive public education and awareness creation campaign on the methods and benefits of renewable energy and energy conservation measures

[103] Different models used to grant geographic concessions to SHS providers can yield wide-ranging results. Some observers have lauded the approaches being used in Rwanda, Nigeria, Togo and DRC as highly successful while, there has been criticism of the approach deployed in Senegal.

[104] Innovative models are emerging for entire geographic areas to be concessioned to integrated private energy services operators who may offer an appropriate mix of solutions within their franchised area (i.e. a mix of SHS, rooftop solar, specialized systems for productive use, mini-grids and micro-grids). This is being piloted by the Shell Foundation in several countries.

	d. Lack of standardized contracts for energy services provided by private system operators to public facilities	d. Help Government, trade associations or civic society organizations develop model bilateral PPA and Energy Services Contracts for small scale IPPs and ESCOs to sell power or deliver energy services to public facilities (i.e. schools, healthcare facilities) or deliver solar street lighting services to municipalities
	e. Insufficient protection for stranded investments	e. Help Government develop proper procedures and guidelines to protect against stranded investments from competition among all on-grid and off-grid rural electrification approaches[105]
5. Business Model Regulation	**A. Lack of understanding about different pricing schemes and business models offered by stand-alone solar system developers**	a. Support capacity building of regulators, Government, and non-Government stakeholders about different pricing schemes offered by stand-alone solar system providers to improve understanding and help avoid unnecessary interventions to regulate[106] b. Support regulators and off-grid enterprises to collaborate specifically on developing pricing schemes for productive use market segment[107] c. Support off-grid entrepreneurs and telecommunications companies in building the capacity of and fostering linkages between telecommunications companies, mobile money providers and off-grid solar companies to help roll out technology platforms and PAYG business models

Source: Focus Group Discussions; Stakeholder interviews; GreenMax Capital Advisors analysis

[105] As the off-grid sector becomes populated by a variety of different approaches, all private operators are subject to potential stranded investments "when the grid arrives" and even SHS providers can have their assets and revenues threatened when the mini-grid arrives.
[106] The term "pricing schemes" used in this context refers to pricing options offered by standalone solar system providers for SHS, productive use, rooftop solar for public facilities, solar street lighting, etc. that are new, innovative and may be difficult for stakeholders to initially well understand. Whether these are PAYG, Lease to Own, electricity sales, commodity-based pricing, time of use or block pricing, the lack of understanding can often cause stakeholders to ask Government to intervene to "protect consumers" where such regulation of the market could in fact be misguided and unwarranted.
[107] The productive use segment is brand new with SHS providers, mini-grid operators and vendors specialized on a single type of SME or agricultural productive use (i.e. grain mills, water pumps, cocoa processing etc.) all grappling to arrive at attractive approaches to billing for energy services. This is an area where TA support is much needed to help all stakeholders sort out fair and practical approaches.

1.4 Development Initiatives

1.4.1 National Government Initiatives

The Government, through the MoE, has put in place several key strategic plans and roadmaps to address rural electrification and development of the off-grid sector (**Table 8**).

Table 8: National Government Off-Grid Development Programs

Project/Program	Timeline	Market Segments	Description
National Electrification Scheme	1989 - 2020	Rural electrification, grid extension	• Serves as the principal instrument leading the efforts of extending electricity to all parts of the country over a thirty-year period • First phase covers the connection of all district capitals and all towns/villages in proximity to the capitals • Subsequent phases target communities where projects are the most economically viable • Provides electricity for local industry, commercial activities and domestic use • The NES program has received funding from several donor agencies, including the World Bank, DANIDA and JICA.[108]
Strategic National Energy Plan	2006-2020	Renewable energy, rural electrification	• Main goal is to contribute to the development of the energy market by providing viable and efficient energy services • Sets a target of 10% renewables in the energy mix and 30% electrification rate in rural areas by 2020.
National Energy Policy	2010	General energy policy	• Supports the use of decentralized off-grid alternative technologies (such as solar PV and wind) where they are competitive with conventional electricity supply.
Renewable Energy Act	2011	RE / off-grid	• Includes a provision for off-grid electrification in isolated communities

1.4.2 DFI and Donor Programs

The Off-grid Energy Challenge, the Green Africa Power (GAP) Program, and the Millennium Challenge Corporation (MCC) Ghana Compact are the three foremost donor programs enhancing rural energy access in Ghana. Additional bilateral and multilateral initiatives are listed in **Table 9**.

[108] "National Electrification Scheme (NES), Master Plan Review (2011 – 2020)," Ministry of Energy of Ghana: http://www.mida.gov.gh/pages/view/NES_Master_Plan_Review_Executive_Summary_Main_Report.pdf/111

Table 9: DFI and Donor-Funded Off-Grid Development Programs

Project/Program	Sponsor	Timeline	Market Segments	Description
Ghana Off-Grid Energy Challenge	USADF, Power Africa	2013-2014	Rural electrification	• The Off-Grid Energy Challenge was launched in 2013 to bring affordable clean energy to rural communities across Africa • Since 2013, over USD 7M has been invested in 75 energy entrepreneurs in nine countries to provide off-grid energy solutions to rural communities • In 2014, seven solar energy companies in Ghana won the challenge and were awarded with grants of USD 100,000 each to provide off-grid solutions
Millennium Challenge Corporation (MCC) Ghana Compact	Millennium Challenge Corporation (MCC)	2014-Present	Power generation, distribution, rural electrification	• The MCC and the Government of Ghana entered into a USD 498 million compact in 2014, the largest Power Africa transaction thus far • Designed to improve the commercial viability of Ghana's power sector across three main areas: power generation, distribution, and access to energy in rural areas • Also supports the improvement of Ghana's climate resiliency through the promotion of various renewable energy and energy efficiency projects
Scaling Up Renewable Energy Programme (SREP)	CIF, AfDB, WB	2014-Present	Renewable energy mini-grid, stand-alone solar PV systems	• One the four key projects of Ghana's SREP Program is focused on renewable energy mini-grids and stand-alone solar PV systems. • USD 899,800 from the CIF is dedicated to the development of Renewable Mini-Grids and Stand-Alone solar systems
Green Africa Power (GAP) Program	Private Infrastructure Development Group (PIDG)	Ended in 2014	Renewable energy, rural electrification	• The Green Africa Power (GAP) program, which is managed by Camco Clean Energy Limited, is a financing facility which offers debt and credit lines to private developers of Renewable Energy projects in Ghana
Power Africa	USAID		Rural electrification	• Power Africa is assisting Ghana in partnership with private US company Weldy-Lamont to connect more than 67,000 rural households, as part of the government of Ghana's Self-Help Electrification Program.
En-Dev	Multi-donor partnership		Solar PV	• In Ghana, EnDev's intervention focuses on supporting 30 small-scale farmers using solar water pumps for irrigation. Sales-based grants is the main incentive provided to the private sector selling and installing PV pumps.

1.4.3 Other Initiatives

Outside of the Government and DFI/donor initiatives mentioned above, there are also several non-governmental organization (NGO) programs and other related initiatives in Ghana's off-grid sector.

- **The Centre for Energy, Environment, and Sustainable Development (CEESD):** CEESD is a non-profit organization that offers engineering solutions and consulting services for challenges such as climate change, energy poverty, environmental degradation, and pollution in rural communities across Ghana.[109] After receiving a grant from USAID Power Africa in 2016, CEESD installed 45 SHS for 35 households and 10 small businesses in the Faazo Battor Community.[110]
- **Dassgift Quality Foundation:** Daasgift has designed a number of demands driven microfinance products and services that seek to enhance access to micro finance services; one of their main target markets is solar kit systems and solutions.
- **Rural Action Alliance Programme (RAAP):** RAAP is an NGO that aims to tackle poverty in Ghana. In 2012, RAAP provided 5000 school children in the Jirapa district with solar light bulbs, so they could study at night.[111]
- **Kumsai Institute of Technology, Energy and Environment (KITE):** KITE is Not-for-Profit development organization that is a leading actor in the Ghanaian Energy, Technology, and Environment sectors. With a unique capacity in the development and implementation of public benefit projects, KITE covers all ten regions of Ghana. KITE is currently working on an ongoing project that seeks to equip maternal health facilities in areas with solar suitcases. These suitcases provide sustainable power for lighting, charging of mobile phones, and fetal heart beat monitors to areas that have unreliable power.[112]
- **Greener Impact International (GIL):** GIL distributed 500,000 solar lanterns to rural communities in 2014.[113]
- **Saha Global**: The US-based NGO is helping to bring solar power and clean water to dozens of small villages across northern Ghana.[114]

[109] "CEESD Ghana," CEESD, (2018): http://www.ceesdghana.org/index.php/about-us
[110] "Power Africa Off-Grid Energy Grants Portfolio," Power Africa, (2017)
[111] "Rural Action Alliance Programme," Crossroads Global Hand, (2018)
[112] "We Care Solar," KITE, (2017): http://kiteonline.net/we-care-solar-wcs/
[113] "Greener Impact International to Distribute 500,000 Solar Lamps to Rural Communities in Ghana", Greener Impact International, (2014): http://greenerimpact.org/greener-impact-international-to-distribute-500000-solar-lamps-to-rural-communities-in-ghana/
[114] "Ghana, Africa's Frontier in Pay-As-You-Go Solar Charging," Energy and Carbon, (2016): http://energyandcarbon.com/ghana-africas-frontier-pay-go-solar-charging/

II. OFF-GRID SOLAR PV MARKET ASSESSMENT

This section presents the overall market assessment for off-grid solar (OGS) energy systems in Ghana. **Section 2.1** provides an overview of the current household off-grid energy situation and estimates potential household market demand for solar energy systems. **Section 2.2** introduces institutional off-grid energy demand and the potential of solar to supply this market. **Section 2.3** evaluates the demand for off-grid solar to serve productive use applications. **Section 2.4** examines the existing off-grid solar product supply chain in the country. **Table 10** summarizes the overall total cash market potential for OGS systems from each of the analyzed market segments. **Annex 2** provides an overview of the Task 2 methodology.

It should be noted that the Task 2 market sizing assesses the total *potential* demand for off-grid solar, as well as variables that affect demand, such as changes in population density, household income, expansion of national grids and access to finance, among other factors. This data will support policymakers and practitioners as they assess market potential over time. However, the quantitative demand estimate has not been revised to reflect *realistic* market potential. Many other factors and market failures will prevent the full realization of this total market potential, and these will vary by market segment.

For household demand, the off-grid solar market is already tangible. Still, many factors will affect household demand for solar products, such as distribution realties, consumer education, competing economic priorities for households, financial shocks, etc. The institutional market will be affected largely by government and donor budget allocations along with the potential for community-based finance. The productive use market is perhaps the least concrete. Considered a relatively new market segment for the off-grid solar industry, productive use market dynamics are not yet well understood. The ability to realize potential productive use market demand will also be affected by many of the factors that commonly determine enterprise prospects in the country, including infrastructure, rural distribution, marketing, access to finance, insecurity, regulation, etc. The data presented in this report is intended to provide a baseline for future research.

Table 10: Indicative Total Cash Market Potential for Off-Grid Solar PV Products in Ghana, 2018

Off-Grid Market Segment	Annualized Cash Demand (Units)	Annualized Cash Demand (kW)	Annualized Cash Market Value (USD)	Financed Market Value (USD)
Household				
Pico solar	57,667	173	$2,595,027	$0.00
Plug and play	10,984	110	$1,373,030	$48,056,048
Small SHS	3,295	165	$823,818	$5,766,726
Medium and Large SHS	0	0	$0.00	$6,178,635
Household Subtotal	**71,946**	**448**	**$4,791,875**	**$60,001,409**
Institutional				
Water supply	554	2,289	$5,721,875	-
Healthcare facilities	252	189	$470,713	-
Primary and secondary schools	83	52	$149,490	-
Public lighting	109	55	$164,100	-
Institutional Subtotal	**998**	**2,585**	**$6,506,178**	**-**
Productive Use				
SME applications for microenterprises	1,127	282	$704,500	-
Value-added applications	265,055	39,137	$190,202,086	-
Connectivity / ICT (phone charging)	17,381	6,952	$14,982,022	-
Productive Use Subtotal	**283,563**	**46,371**	**$205,888,608**	**-**
TOTAL	**356,07**	**49,404**	**$217,186,661**	

Source: African Solar Designs analysis

2.1 Demand – Households

This section analyzes the main characteristics of the household (HH) OGS demand in Ghana. Section 2.1.1 provides an overview of the household market segment, including its geographic components. Section 2.1.2 analyzes current household ability and willingness to pay for electricity services to estimate the total potential household sector demand. From this data, the potential household market for off-grid solar products is then calculated for both cash purchases (Section 2.1.3) and financed (2.1.4) purchases. Section 2.1.5 assesses consumer perceptions, interest, and awareness on OGS.

2.1.1 Overview of Household Market Segment

According to the International Energy Agency (IEA), in 2016 there were 1.3 million households (4.6 million people) in Ghana without access to electricity.[115] In that year, an estimated 84% of the population had access to electricity, with the rate of access at 95% in urban areas and 71% in rural areas – significantly higher than in many other countries in West Africa and the Sahel. As shown in **Table 11**, the vast majority of households without access are in the lowest income quintile, living in rural areas.

In Ghana, the government objective for rural electrification is to stimulate socio-economic development, improve rural livelihood and reduce rural urban migration. Currently in Ghana, there is no community with a population above 2000 by policy which is not connected to the grid. Efforts by government to promote off-grid solar products are currently geared towards island communities, communities along lakesides and communities where there are difficulty extending the national grid with a population of around 500.

This section gives an introduction to household consumer market segments, their characteristics and size (**Table 11**). It then discusses household sources of income and geographic distribution of off-grid households, both presently and projected over time. This provides context for the next section, 2.1.2, which sizes household segment potential market demand through a series of detailed analyses.

[115] See **Annex 2** for more details.

Table 11: Household Consumer Market Segments[116]

Income Quintile	% w/o access	# HH w/o access	Avg. GDP per HH per year	Energy Tier	% w/o access	# HH w/o access	Avg. GDP per HH per year	Energy Tier	% w/o access	# HH w/o access	Avg. GDP per HH per year	Energy Tier	Geographic segments	Description
	2018 Scenario				2023 Scenario				2030 Scenario					
Highest 20%	1%	16,476	14,129	Tier 3	0.5%	9,356	$20,297	Tier 3	0.1%	2,179	$30,852	Tier 3	High income rural	• Small portion of rural households using a petrol generator set • Has a demonstrated ability to pay for solar off-grid systems
													Mid to high income urban	• Professionals, business owners and salaried people are likely to be connected to the grid. • Small portion of households without grid access desire replacement to generator power[117]
Fourth 20%	2%	32,953	$6,407	Tier 3	1%	18,712	$9,203	Tier 3	0.2%	4,358	$13,989	Tier 3	Low income peri-urban / urban "under-grid"	• Low income urban population engaged in SME work or casual labor • Lives near grid but cannot afford or does not have access to connection
Third 20%	3%	49,429	$4,271	Tier 3	1.5%	28,069	$6,135	Tier 3	0.3%	6,537	$9,326	Tier 3		
Second 20%	4%	65,905	$2,867	Tier 2	2%	37,425	$4,118	Tier 2	0.4%	8,717	$6,260	Tier 2	Low income rural	• Engaged in farming, or SME • Lives more than 15km from the nearest grid connection.
Lowest 20%	70%	1,153,345	$1,580	Tiers 1, 1.5	55.2%	1,033,741	$2,269	Tiers 1, 1.5	16.1%	351,122	$3,449	Tiers 1, 1.5		
Total households without access to electricity		**1,318,109**			**Total**	**1,127,304**			**Total**	**372,913**				

Source: IEA and World Bank; African Solar Designs analysis

[116] See **Annex 1** and **Annex 2** for more details.

[117] This model does not consider connected on-grid households that would purchase OGS systems as a back-up power system due to poor grid quality and reliability. The "households without electricity access" estimates shown here include households without electricity connections, either from a grid connection or from a renewable energy-based off-grid source. This does include "under-grid" households, largely in the lower income quintiles, that live within grid vicinity but are currently not connected. 2023 and 2030 projections assume that under-grid households will become connected in those years.

- **Off-grid household characteristics**

Ghana has a significantly lower incidence of poverty than many of its neighboring countries, as shown in **Table 12**. For example, roughly 45% of the population in Nigeria and over half (52%) of the population in Sierra Leone lives below USD 1.90 a day, compared to just 12% in Ghana.

Table 12: Poverty Headcount in Ghana, 2013

Poverty headcount ratio	% of population
Lives at or below $1.90 a day*	12%
Lives at or below $3.20 a day*	32.5%
Lives at or below $5.50 a day*	60.5%

*2011 PPP

Source: World Bank

As shown in **Table 11**, the largest household market segments for off-grid solar products in the country are rural households in the lowest income quintile. For these households, ability to pay will still be low. As with many countries in this region of West Africa, economic activity is concentrated in the southern coastal area around wealthy cities such as the capital Accra, Takoradi and Kumasi where mining, forestry and cocoa growing drive higher household incomes. Agricultural households in the north will have significantly lower and irregular incomes.

- **Geographic components of the solar market**

Despite the extension of Ghana's electricity grid into northern regions, the largest concentration of off-grid households is found in the Northern and Brong Ahafo districts in the north.

The total number of off-grid households and their geographic distribution will also change slightly over time. To analyze the potential OGS market over time, GIS maps were prepared from demographic information to present potential market areas for OGS. GIS calculations consider drivers of off-grid household market change including grid extension around current urban and peri-urban centers, mini-grid development for more densely populated rural areas, and population growth. Sources of information for the maps presented below (**Figures 19-22)** can be found in **Annex 1**.

GIS maps shown here are for 2018-2023 and 2030. Data shown for 2018-2023 includes information on existing grid lines only. The data of planned "future lines" is not broken down in enough detail to show in which year future lines will be built, so an assumption was made that all future lines would be built after 2023 but prior to 2030.

As shown in the maps and chart summaries below **(Figures 19-22)**, the total size of the OGS market will decrease over time, while also becoming more concentrated in more remote regions. This has implications for solar product market long-term business models, which will need to consider broader distribution areas as the total number of off-grid households declines. Lessons learned in central districts will be valuable in extending market reach to more remote areas, as will new and more innovative business model approaches.

For example, by 2030 the Greater Accra region will no longer be a market for off-grid households. Northern and Brong Ahafo will remain the regions with the highest number and concentration of off-grid households. Markets in Western and Ashanti will also shrink significantly.

Figure 19: Distribution of Potential Off-Grid Households by Region, 2023

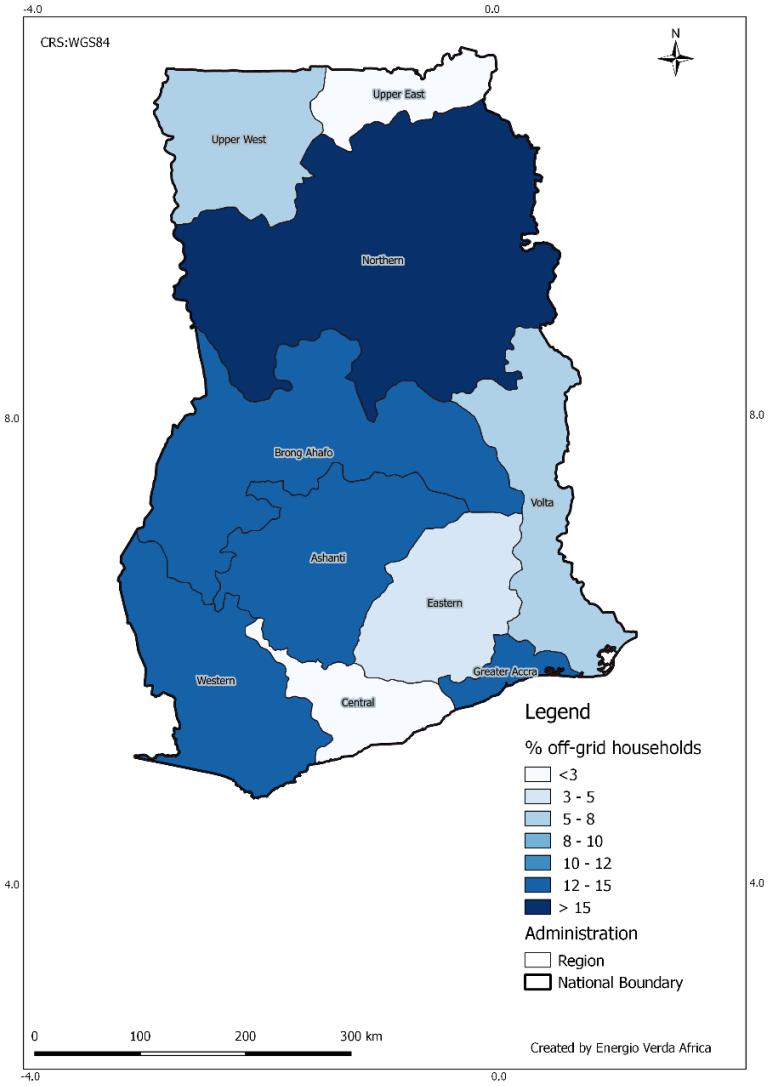
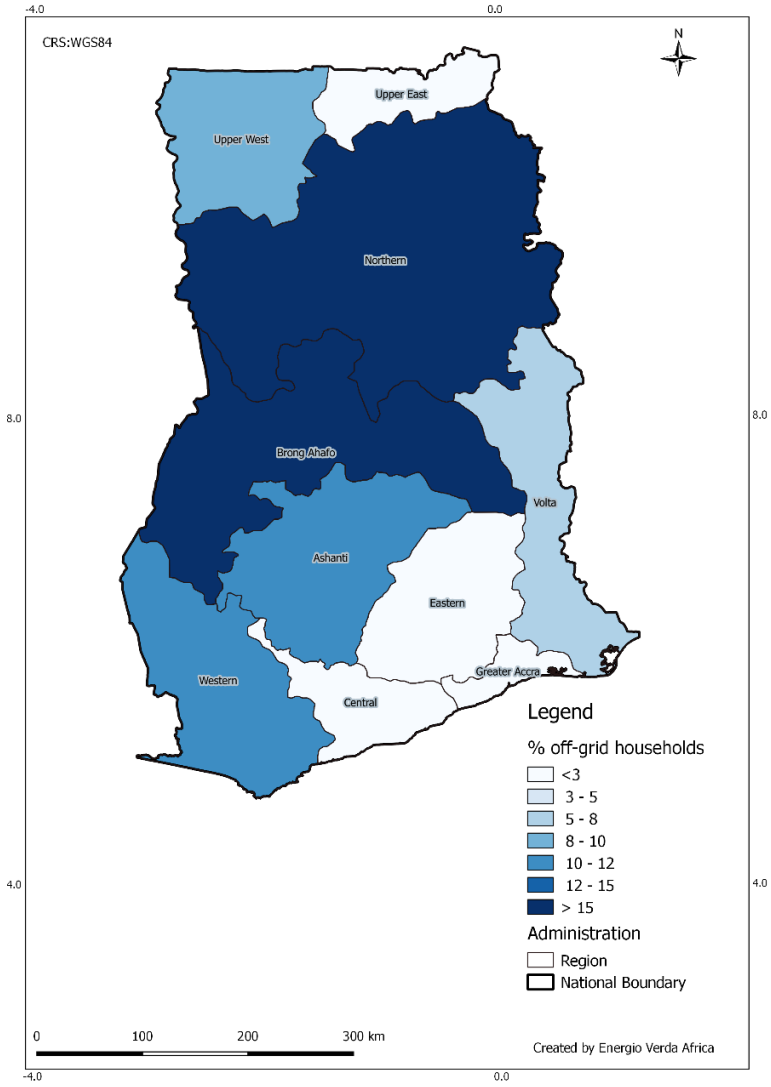
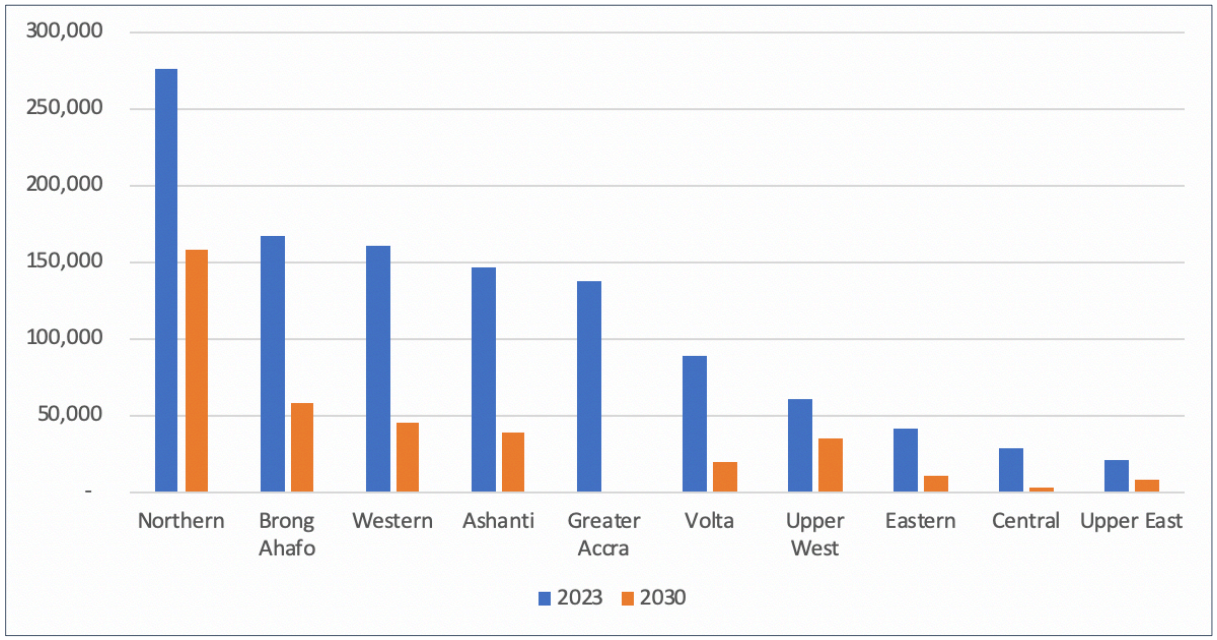


Figure 20: Distribution of Potential Off-Grid Households by Region, 2030



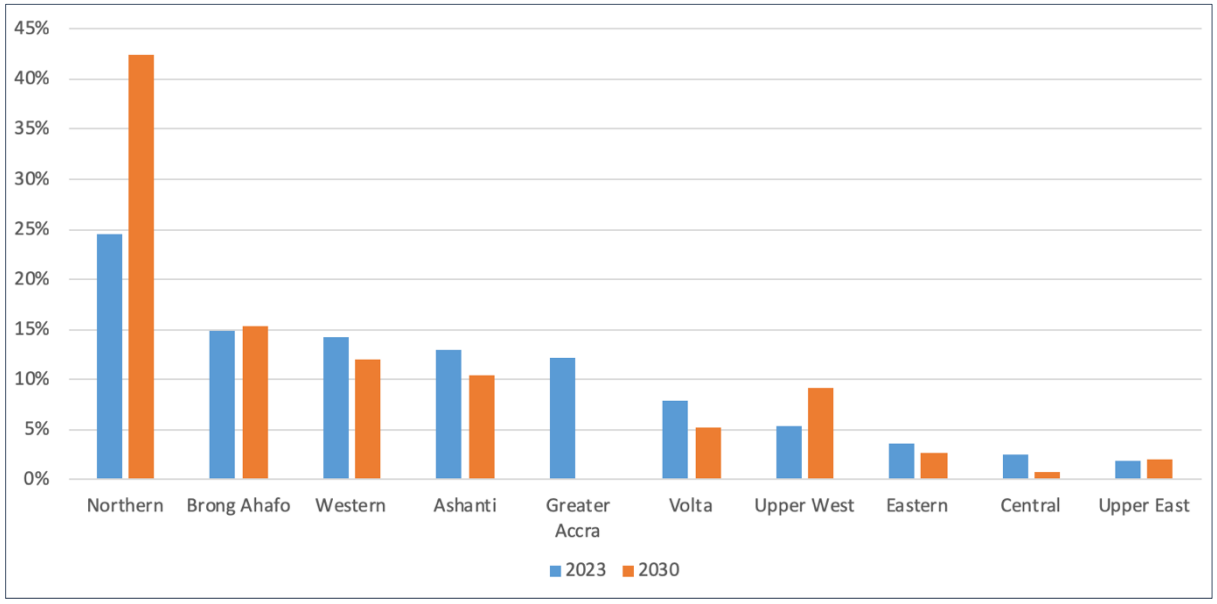
Source: Energio Verda Africa GIS analysis

Figure 21: Estimated Number of Off-Grid Households by Region, 2023 and 2030



Source: Energio Verda Africa GIS analysis

Figure 22: Estimated Percentage of Off-Grid Households by Region, 2023 and 2030



Source: Energio Verda Africa GIS analysis

2.1.2 Analysis of Household Market Segment Demand

In order to calculate total potential household demand for off-grid solar products for the national market, this section examines several indicators:

- Household usage and costs of typical rural energy fuels and devices (non-solar)
- How these rural energy technologies align with typical access to "energy tiers"
- Cost of off-grid solar products alternatives, by energy tier
- Household uptake of solar products thus far
- Potential household demand based on household income quintiles

From this data, the potential household market for off-grid solar products is then calculated for both cash purchases and financed purchases.

➢ **Consumption and expenditures on typical rural energy fuels and devices (non-solar)**

According to feedback from focus group discussion (FGD) participants, candles, kerosene, dry cell batteries, car batteries and generators are the most commonly used sources of energy in rural Ghana.

Table 13 shows the typical monthly cost of using common rural energy technologies. Household use of different types and amounts of energy technologies is associated with different energy access tiers, as defined in the Multi-Tier Energy Access Framework. For example, a household using one battery powered lantern and one charged cell phone would fall under the Tier 1 level of energy access. A household using two lanterns, one cell phone and a radio would be in Tier 1.5.

These tiers are defined in **Table 14**. Establishing an average monthly household expenditure for each energy tier using common rural technologies shows how household income level aligns with energy tiers. Secondly, it provides a basis to compare these costs to solar products that can offer an equivalent level of service by energy tier. This in turn reveals potential household savings by switching to solar products, as shown in **Figure 23** and **Table 15**.

It should be emphasized that even where households can be categorized into energy tiers by their income, few households actually pay full typical monthly costs because they do not have the available income. In reality, household income is highly variable throughout the year, and they simply do without service for portions of the month and year when cash is not available. This accounts for the difference between "typical monthly costs" (which are real) and "equivalent service costs" (which would be required to maintain the tier-level service). For example, very few households could actually run generators for the number of hours that would enable full tier 3 level services.

Table 13: Rural Energy Technology and Costs[118]

Technology	Description	Average Life (Years)	# of Units/ Month	Unit Operating Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)	Unit Capital Cost (USD)	Typical Monthly Cost (USD)
					2018 Scenario		2023 Scenario		2030 Scenario	
Torch lights/Electric Lanterns	Torch lights/electric lanterns powered by D-type, AA-type or AAA-type batteries	0.5	16	$0.22	$2.00	$3.52	$2.38	$4.19	$3.58	$6.30
Cell Phone Charging	Done at a charging station	-	8	$0.21	$0.00	$1.70	$0.00	$2.03	$0.00	$3.05
Smart Phone Charging	Done at a charging station	-	16	$0.21	$0.00	$3.40	$0.00	$4.06	$0.00	$6.10
Battery-powered DC Radio	Radio powered by dry cells replaced two times per month	-	8	$0.22	$0.00	$1.76	$0.00	$2.10	$0.00	$3.15
Lead Acid Battery-powered DC TV	DC TV powered by lead acid battery recharged once per week	2	4	$1.00	$50.00	$4.00	$59.55	$4.76	$89.54	$7.16
Small Petrol Generator	Most popular rural generator for basic use is 0.9kW (for phone charging, lighting, TV, fan, music system)	2	30	$1.05	$100.00	$31.50	$119.10	$37.52	$179.08	$56.41

Source: African Solar Designs analysis

[118] Data from FGDs, field surveys and various published sources.

Table 14: Typical Tier-Based Energy Costs

Device category and indicative energy supplied	Appliances and level of service	Non-solar devices used to power tier requirement	Typical Monthly Cost (USD) 2018	Typical Monthly Cost (USD) 2023	Typical Monthly Cost (USD) 2030
Tier 0 No electricity	• Characterized by complete lack of electricity services • Many cash-poor consumers are in this situation part of each month when they don't have money to buy dry cells or charge phones	• Rely solely on kerosene, wood and other fuel sources for cooking and lighting	• Subsistence level of energy • Absolute energy poverty	• Subsistence level of energy • Absolute energy poverty	• Subsistence level of energy • Absolute energy poverty
Tier 1 Range: 1 to 20 Wh/day	• Access to one torch powered by dry cell batteries • One cell phone powered by charging service	• One battery-powered light requires dry cell replacement on weekly basis • One cell phone charged 8 times per month	$5.22	$6.22	$9.35
Tier 1.5 Range: 20 to 100 Wh/day	• Access to one torch and one lantern each powered by dry cells • One cell phone powered by charging service • Radio powered by dry cells	• Two battery-powered light points require dry cell replacement on weekly basis • One cell phone charged 8 times per month • Radio dry cells replaced two times per month	$10.50	$12.51	$18.81
Tier 2 Range: 55 to 500 Wh/day	• One torch and two lanterns powered by dry cells • One cell phone and one smart phone powered by charge service • Radio • DC TV	• Three battery light points require dry cell replacement on weekly basis • One cell phone charged 8 times per month and one smart phone charged 16 times per month • TV/Radio powered by lead acid battery recharged once per week	$19.67	$23.42	$35.22
Tier 3 Range: 500 to 2500 Wh/day	• Five lighting points • Multiple cell/smart phones • AC radio and music system • AC TV	• Generator powers a set of appliances	$31.50	$37.52	$56.41

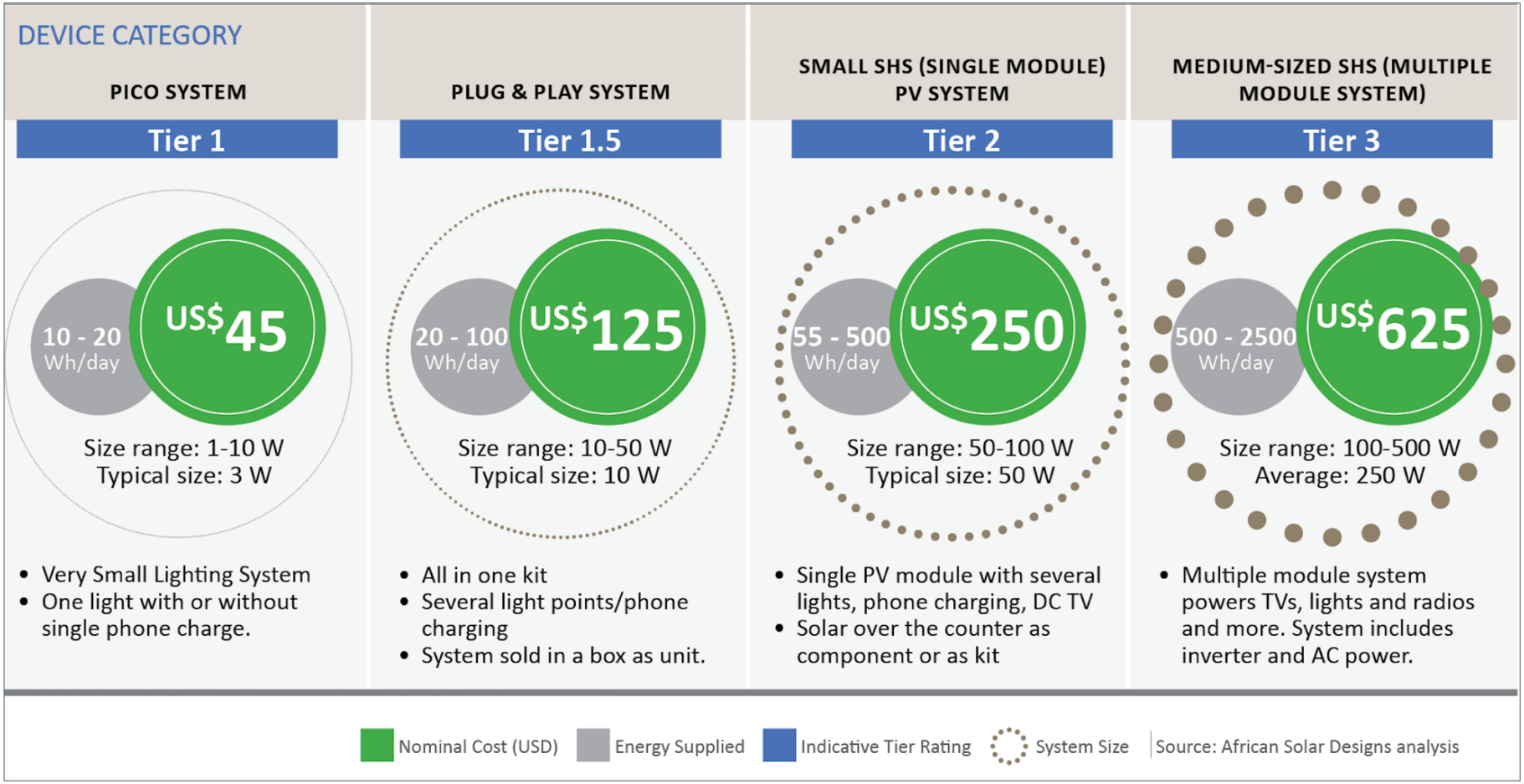
Source: African Solar Designs analysis

Per **Table 14**, it can be seen that, given the purchase price of dry cells and the cost of phone charging, the "ideal" electricity availability is extremely difficult to sustain. This is especially true where there is a high incidence of poverty in rural areas and lack of regular incomes. In reality, households often must reduce their energy consumption when cash is not available. This means that even a Tier 2 level family might drop to Tier 1 for a week each month when cash is not available to pay for phone charging or dry cell purchase.

- **Household Solar PV System Types**

Solar PV systems can provide lower cost and higher levels of service than existing dry cell, phone charging and generator options. In order to model how solar systems can meet existing energy use categories, levels of service and ability to pay, four types of household solar systems are configured to match the tier-based demands of off-grid communities. The system descriptions, energy outputs, prices, tier ratings and target consumer groups are listed in **Figure 23**.

Figure 23: Household PV System Descriptions and Market Segments



Source: African Solar Designs analysis

- **Current usage and procurement process for household solar products**

Many households in Ghana are already using off-grid solar products. FGD participants estimated that the regions of Upper East, Upper West, Northern, Brong Ahafo, Ashanti, Greater Accra, Volta and Eastern all have a 90% awareness level for solar products, citing the Ministry of Energy. Households in the Western and Central regions have relatively lower awareness and usage rates, estimated at perhaps 30%. One FGD participant stated: "If you come to the western region, when you travel to most of the communities, most of them do not know solar and they don't know what it is about."

- **Potential household demand for off-grid solar products**

Looking beyond current use of off-grid solar products by households, this study analyzes potential for OGS market development by estimating potential household demand based on household income. Household income shown in **Table 15** is sourced from World Bank demographic data based on household surveys, which reports income by population quintiles. From household income, potential for energy spending is estimated as 10% of monthly income (see methodology annex). Future scenarios project higher energy budgets as household incomes rise with economic development over time. In all scenarios, the large majority of off-grid households will fall under the lowest income quintile.

Table 15: Energy Expenditure of Different Income Groups

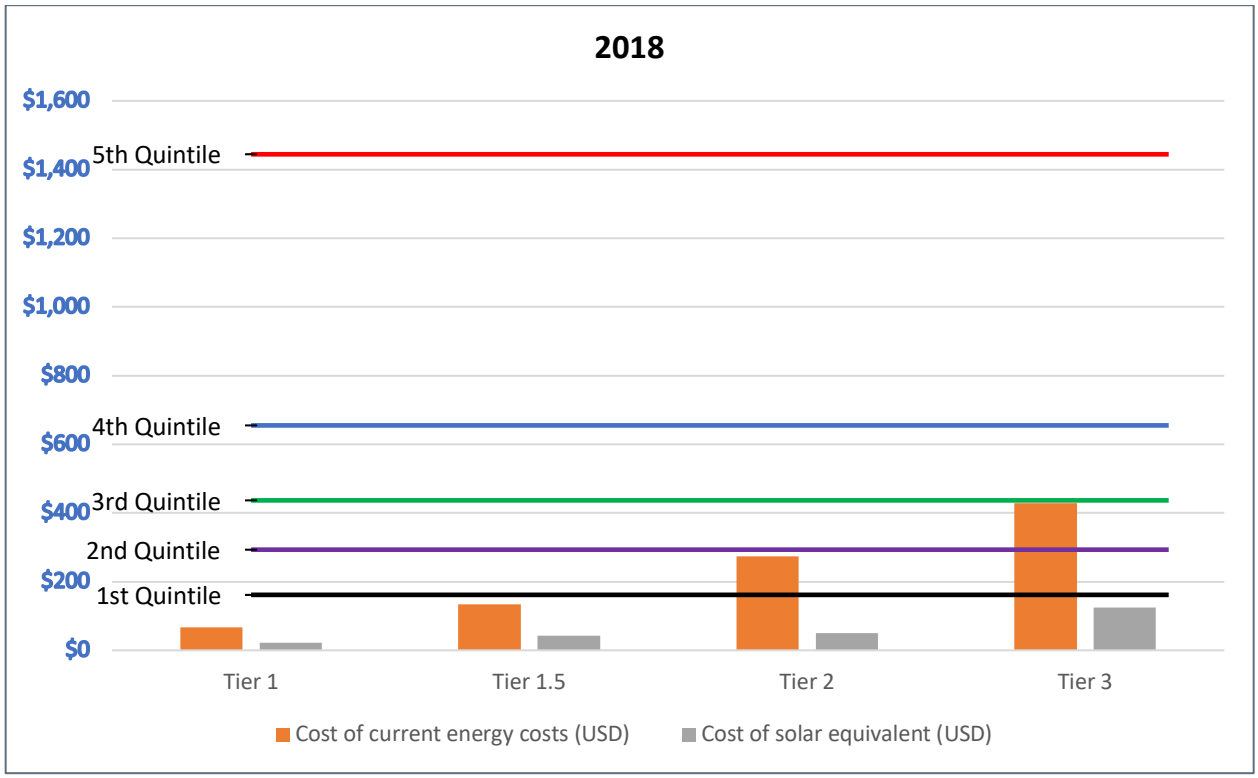
Population Income Quintiles	Per Capita Income (USD per month)	Household Income (USD per month)	Energy as % of Income	Monthly Energy Budget (USD)
2018 Scenario				
Lowest Quintile of Population	$37.61	$131.64	10%	$13.16
2nd Quintile of Population	$68.26	$238.90	10%	$23.89
3rd Quintile of Population	$101.69	$355.92	10%	$35.59
4th Quintile of Population	$152.54	$533.88	10%	$53.39
Highest Quintile of Population	$336.42	$1,177.45	10%	$117.75
2023 Scenario				
Lowest Quintile of Population	$54.03	$189.10	10%	$18.91
2nd Quintile of Population	$98.05	$343.19	10%	$34.32
3rd Quintile of Population	$146.08	$511.28	10%	$51.13
4th Quintile of Population	$219.12	$766.92	10%	$76.69
Highest Quintile of Population	$483.26	$1,691.42	10%	$169.14
2030 Scenario				
Lowest Quintile of Population	$82.13	$287.44	10%	$28.74
2nd Quintile of Population	$149.04	$521.65	10%	$52.17
3rd Quintile of Population	$222.04	$777.16	10%	$77.72
4th Quintile of Population	$333.07	$1,165.74	10%	$116.57
Highest Quintile of Population	$734.57	$2,571.01	10%	$257.10

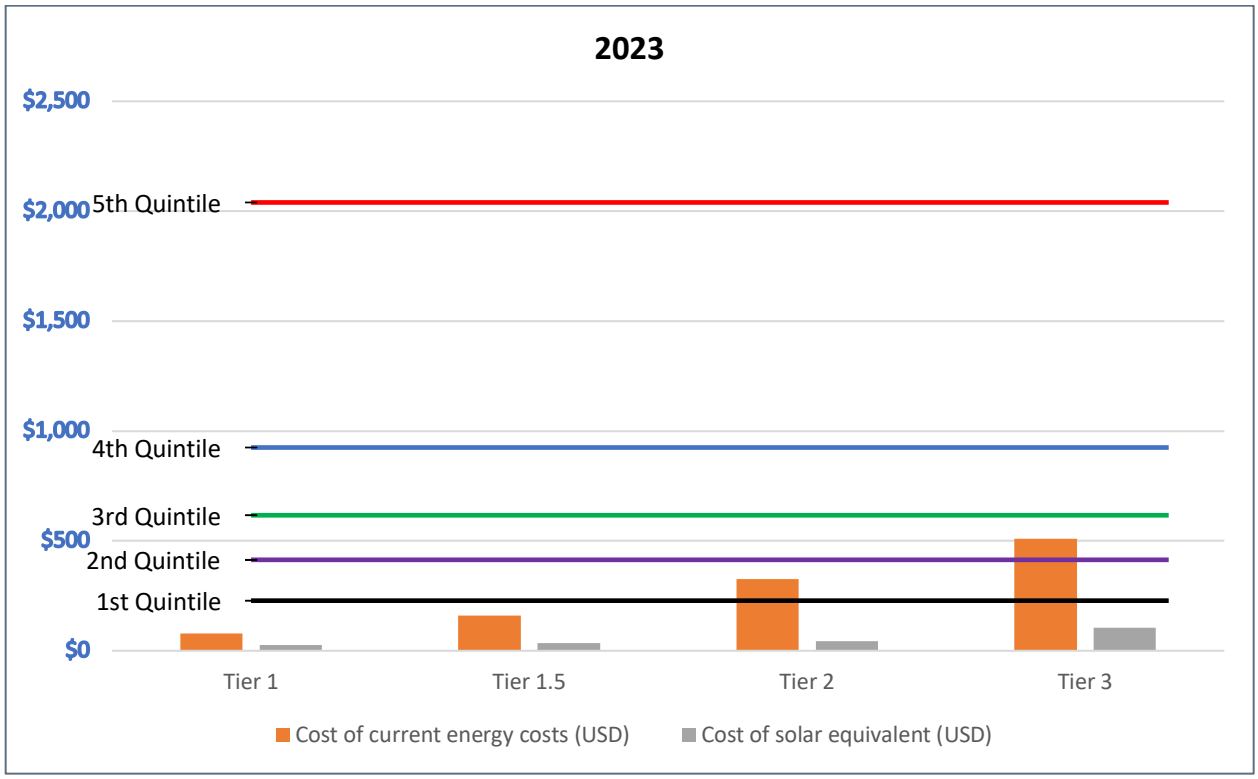
Source: African Solar Designs analysis

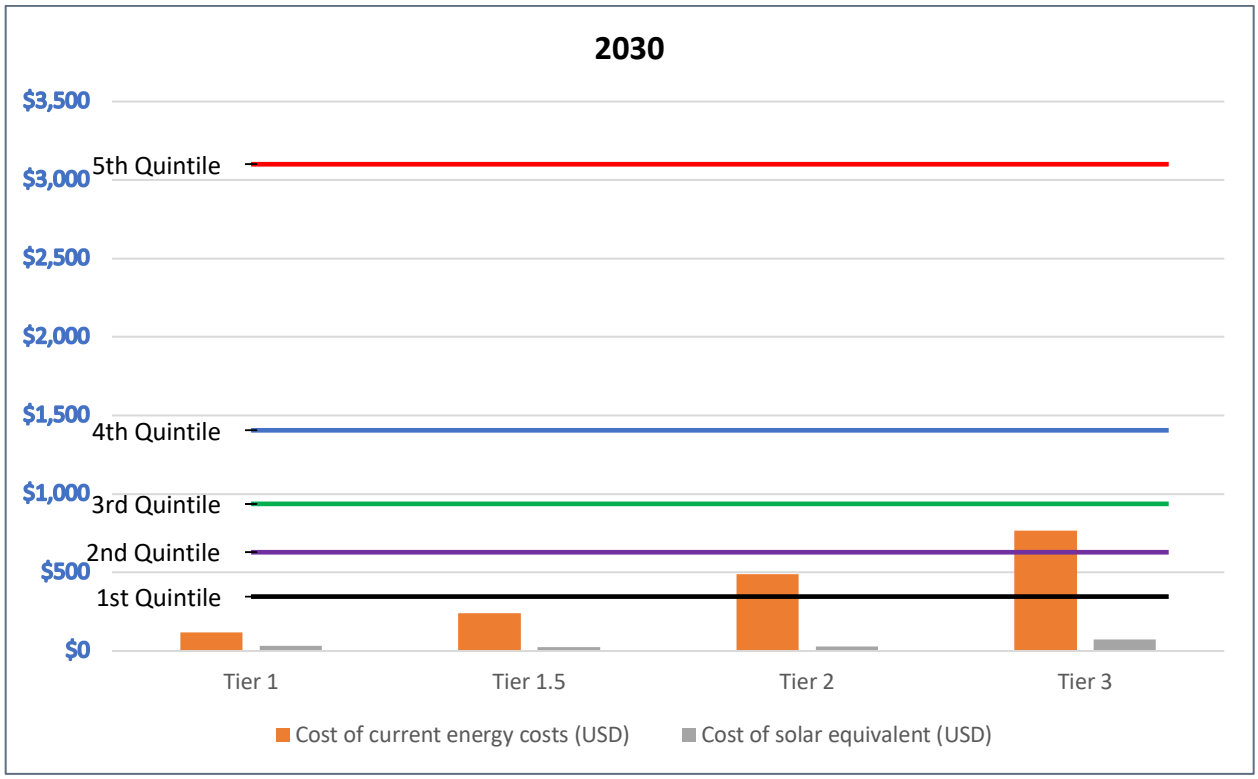
Figure 24 summarizes the preceding data in this section by comparing household energy spending with typical rural energy costs and their solar equivalents. This analysis presents annualized costs (not including financing cost) of current energy technologies for each energy tier, compared with the annual cost of an equivalent solar product. Both the annual costs of current energy technologies and equivalent solar solutions consider the capital costs of the units, and the operating costs considered over the average unit life times.

The data clearly shows strong potential savings for households to switch to solar products. Affordability also increases over time, as the cost of solar technology reduces, while the cost of traditional energy sources increases with inflation, and household income increases. Affordability here is shown by comparing annual income and energy costs over the life of a product. This indicates the need for short term financing, as many households still struggle to pay up front unit capital costs to achieve subsequent savings.

Figure 24: Annual Household Energy Budget by Quintile, Annual Energy Costs and Cost of Solar Equivalents







Source: African Solar Designs analysis

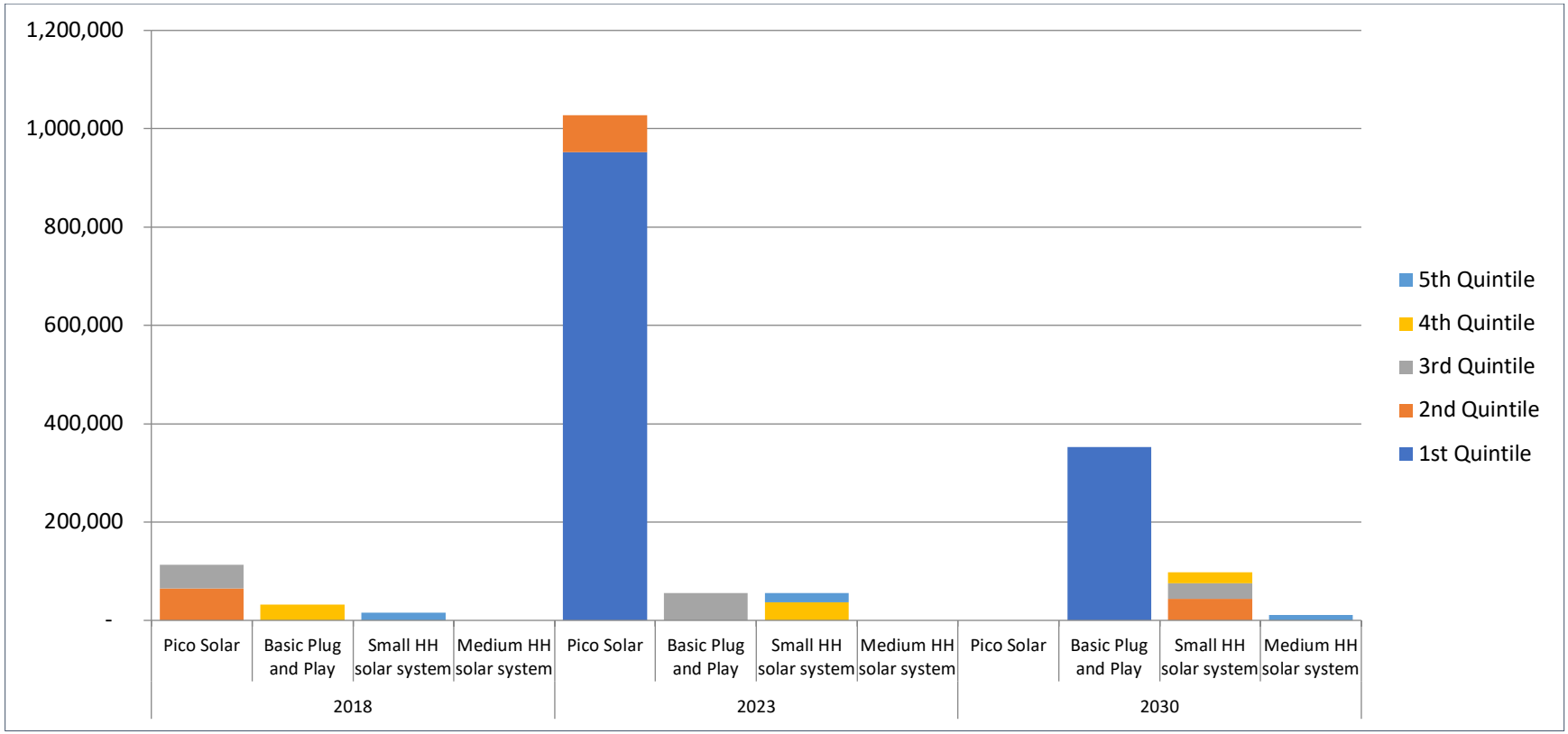
2.1.3 The Market for Household Devices without Consumer Finance

This section analyzes the cash market for various income levels and the corresponding energy services powered by OGS systems they can afford. Modelling of the viable market was based on income quintiles associated with data from the World Bank. The calculations and assumptions made are presented in **Table 15**. It was assumed that for a cash purchase a household is willing to save three months of their current energy expenditure to purchase the OGS system.

Based on the income quintiles and corresponding estimated current energy expenditure, in the 2018 scenario, all the households without access except those in the lowest income quintile can afford an OGS system unfinanced. The households in the lowest quintile, which represent the vast majority of the market without electricity access, cannot afford even a pico solar product. However, in 2023 and 2030, these households (in the lowest income quintile) are able to afford at least one pico solar system unfinanced. Based on the analysis, the need for financing solutions for the lower income quintiles is clear.

The model assumes that each household purchases only one system. It also does not consider on-grid households that would purchase OGS systems as a back-up power system due to poor grid quality and reliability. This market has become a key segment of the more mature OGS markets (e.g. in East Africa), but is not the focus of this study, which is based on sizing the current markets in West Africa, alongside a least cost analysis for future access to energy that prioritizes reliable grid connections where possible.

Figure 25: Estimated Number of Households Able to Afford Cash Purchase of OGS Systems by Income Group



Source: African Solar Designs analysis

Table 16 presents the estimated annualized cash market potential for off-grid solar product sales in the country's household sector.

Table 16: Estimated Cash Market Potential for Household Sector

Solar System	Annualized Demand (Units)	Annualized Demand (kW)	Annualized Market Value (USD)
2018 Scenario			
Pico Solar	57,667	173	$2,595,027
Basic Plug and Play	10,984	110	$1,373,030
Small HH solar system	3,295	165	$823,818
Medium HH solar system	0	0	$0.00
Total	**71,946**	**448**	**$4,791,875**
2023 Scenario			
Pico Solar	535,583	1,607	$26,720,232
Basic Plug and Play	9,356	94	$989,938
Small HH solar system	5,614	281	$1,187,926
Medium HH solar system	0	0	$0.00
Total	**550,553**	**1,982**	**$28,898,096**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	117,041	1,170	$8,392,681
Small HH solar system	3,922	196	$562,542
Medium HH solar system	436	109	$156,262
Total	**121,399**	**1,475**	**$9,111,485**

Source: African Solar Designs analysis

The following considerations should also be taken into account when analyzing this data:

- The most common type of systems which the market can afford on a cash basis are pico and small plug and play systems. Based on available income figures Tier 2 and Tier 3 solutions are less viable for the vast majority of the population in the near term. However, this picture changes significantly with the introduction of financing.
- The model does not adequately address highest quintile and actual sales in the market. Note that the analysis does not predict purchases of Tier 3 equipment and it does not reflect what is happening at the extreme high end of the market. Because the analysis divides the population into relatively wide quintiles, it does not adequately address the very small portion of apex rural (and peri-urban) customers that now use generators.

2.1.4 The Financed Market for Off-Grid Solutions

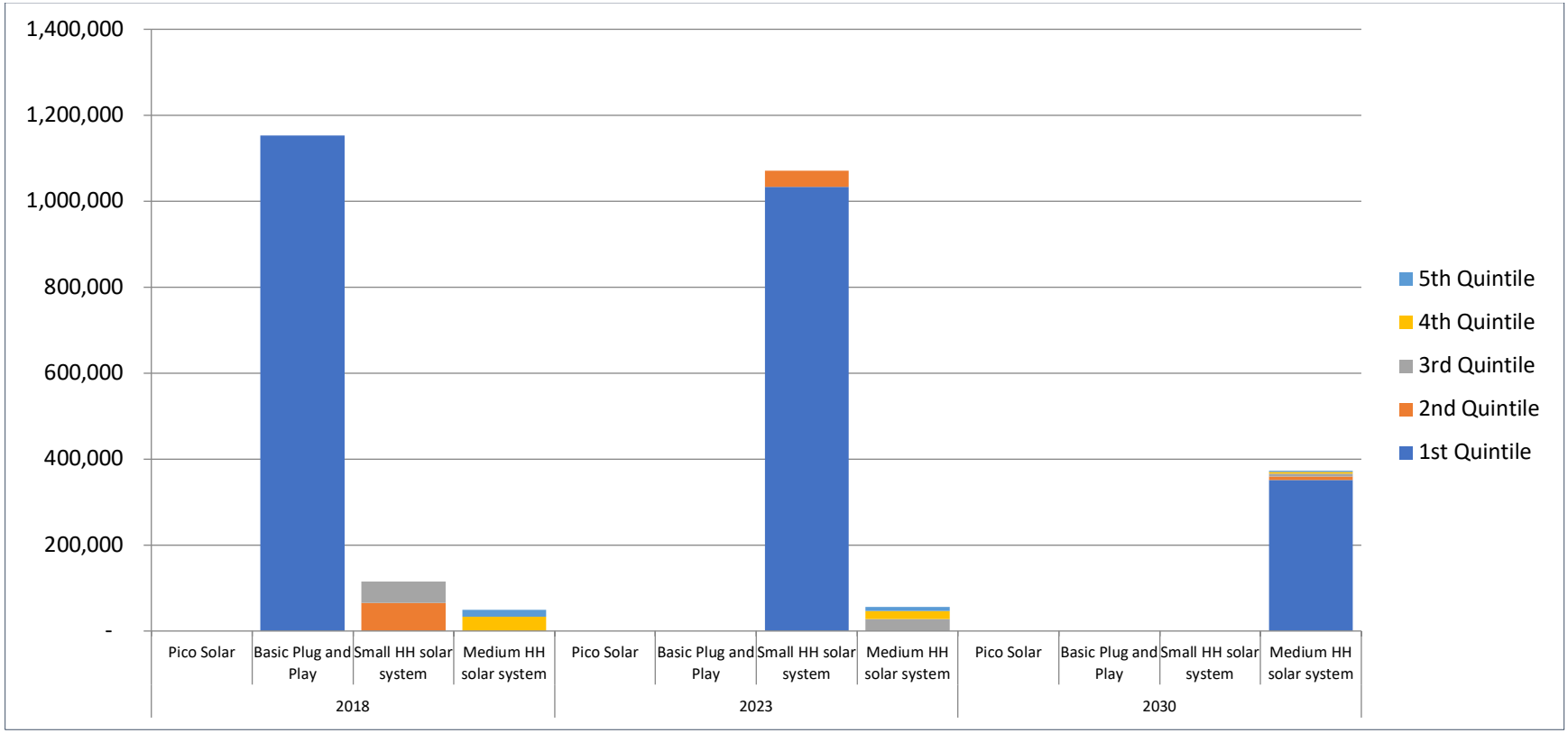
- **Financial Model**

In order to portray the effects of finance, a simple model was prepared that provides OGS system finance with a 70% p.a. interest rate[119] and a 24-month term. The financial model assumes that the households would be willing to save for three months of their current energy expenditure to cover a small upfront deposit of 10% of the system and their current energy expenditure would be used to pay the monthly installments.

This model assumes that each household will purchase the system that offers the highest energy serve level they can afford. As with the cash market model, it assumes that each household purchases one unit each. However, this finance model greatly over-estimates the potential market for credit as both MFIs and PAYG companies would likely be extremely cautious in approving customers. Without concrete data on the loans given to consumers in each income quintile in the country, it is difficult to estimate what the more realistic figures are. Nevertheless, this model does give a clear indication that long loan tenors combined with a low upfront payment would result in significant market transformation. The results of this analysis are presented below.

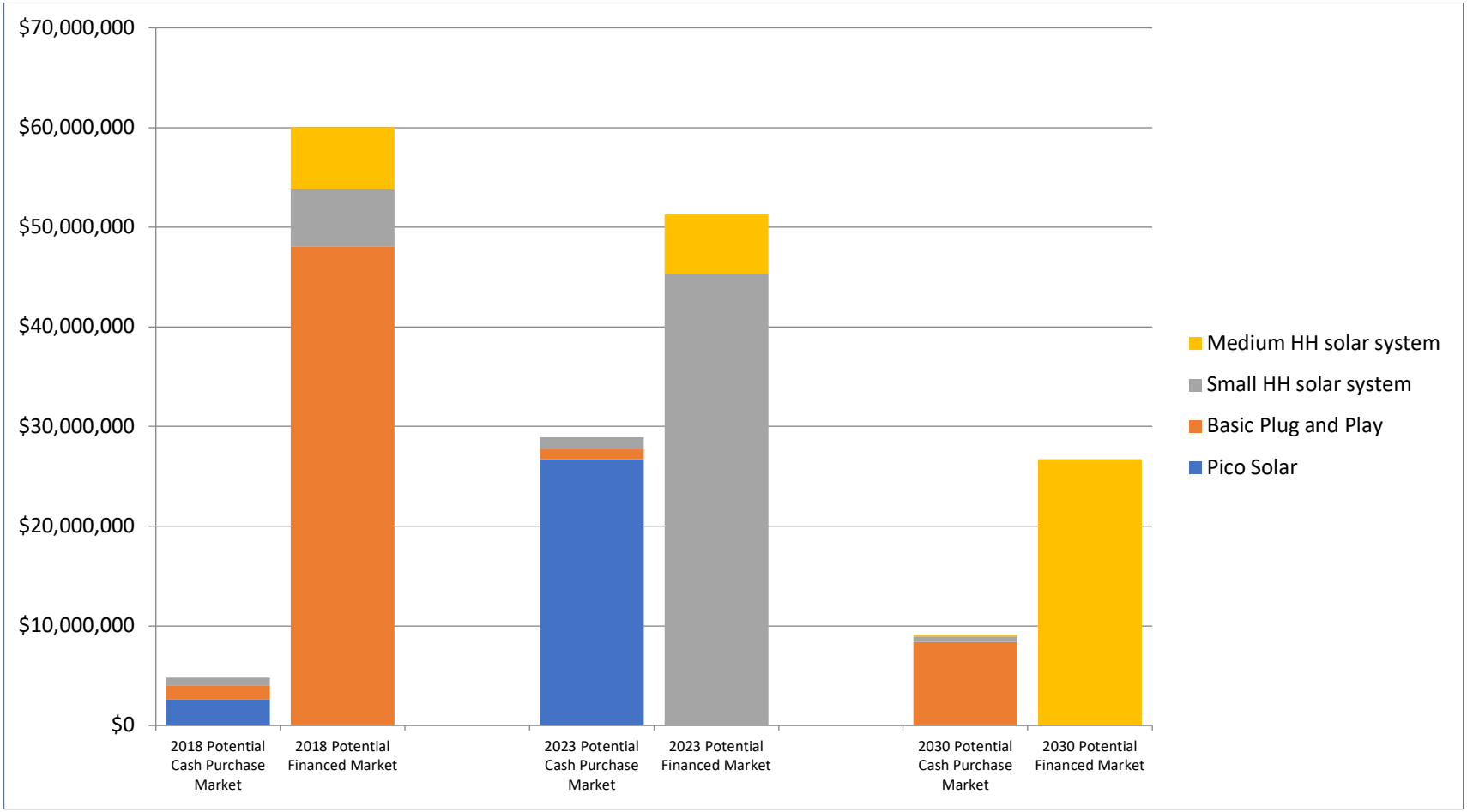
[119] http://citifmonline.com/2015/06/02/gcb-to-maintain-lending-rates/
https://www.myjoyonline.com/business/2016/April-25th/ghana-ranks-second-among-highest-interest-rates-countries.php

Figure 26: Estimated Number of Households Able to Afford Financed OGS Systems by Income Group



Source: African Solar Designs analysis

Figure 27: Estimated Off-Grid Solar Cash and Financed Market Potential for Household Sector by System Type



Source: African Solar Designs analysis

In 2018, without financing, only 164,764 households (12.5% of households without access) in the country could afford an OGS system. However, with financing, 1,318,109 households (100% of off-grid households) could afford an OGS system as the 1,153,345 off-grid HH in the lowest income quintile are enabled to acquire at least one OGS system. Consequently, the annualized potential market size increases from USD 4,791,875 to USD 60,001,409 mainly due to the fact that the households are enabled to purchase larger systems (**Figure 27**).

The least-cost electrification 2023 scenario calculates that 1,127,304 households could be electrified by stand-alone systems. Under this scenario, all the households without access would have the ability to acquire at least one OGS system, however, financing enables them to acquire the larger systems. The annualized potential market size therefore increases from USD 28,898,096 to USD 51,273,529 (**Figure 27**).

The least-cost electrification 2030 scenario calculates that the total number of households that could be electrified by stand-alone systems would drop further to 372,913. Under this scenario as well, all the households without access have the ability to acquire at least one OGS system, however, financing enables them to acquire the larger systems. The annualized potential market size therefore increases from USD 9,111,485 to USD 26,740,660 (**Figure 27**).

Table 17 presents the estimated annualized financed market potential for off-grid solar product sales in the country's household sector.

Table 17: Estimated Financed Market Potential for Household Sector

Solar System	Annualized Demand (Units)	Annualized Demand (kW)	Annualized Market Value (USD)
2018 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	384,448	3,844	$48,056,048
Small HH solar system	23,067	1,153	$5,766,726
Medium HH solar system	9,886	2,471	$6,178,635
Total	**417,401**	**7,468**	**$60,001,409**
2023 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	0	0	$0.00
Small HH solar system	214,233	10,712	$45,333,900
Medium HH solar system	11,227	2,807	$5,939,629
Total	**225,460**	**13,519**	**$51,273,529**
2030 Scenario			
Pico Solar	0	0	$0.00
Basic Plug and Play	0	0	$0.00
Small HH solar system	0	0	$0.00
Medium HH solar system	74,583	18,646	$26,740,660
Total	**74,583**	**18,646**	**$26,740,660**

Source: African Solar Designs analysis

2.1.5 Consumer Perceptions, Interest and Awareness

- **Purchasers of solar are "early adopters" who tend to buy from system integrators as well as hardware traders**

  - **Retail purchasers:** Most purchases are made over-the-counter sales in capital and major cities as cash purchases. As with the consumer migration from kerosene to electric lights, there is a gradual migration from low cost dry-cell electric lamps to solar PV systems. Consumers make purchases in the same shops, and sellers are adapting to changes in demand by offering solar equipment.
  - **High-end consumers:** As elaborated in **Section 2.4**, a small number of early adopting consumers buy from specialized solar integrators who offer quality services and components. A large portion of buyers in this segment opt for systems above 200Wp for residential and small business demand.
  - **PAYG:** As the PAYG market segment is still in its nascent stages, detailed data of PAYG customers is still largely unavailable, although recent experience from East Africa suggests that these customers include both rural and peri-urban inhabitants. The PAYG business model / method is still not widely understood; moreover, there are still questions about how to account for the seasonality of incomes as opposed to regular monthly payment plans.

- **Consumers have a general awareness that solar can economically replace generators and batteries, but they are still largely uninformed about solar electric specifics**

  - While knowledge is gradually improving (particularly for small/pico solar lighting systems) most consumers are not yet educated enough to make informed decisions about solar systems.
  - There are often geographic disparities in awareness levels of OGS products, as households in urban or peri-urban areas tend to have better understanding of solar vis-à-vis rural villages.[120]
  - Consumers are hearing "general messages" (i.e. "solar is good," "solar can be cheap," "solar can be more economical"). These messages need to be translated into more specific understanding of the technology (i.e. what are the options, what products are better than others, where to buy solar, what is a best way to pay for solar, what suppliers are more reliable, how to manage O&M, etc.).
  - Consumers often do not get fair information on the product they are buying. Marketing messages are quite mixed and much 'overpromising' occurs for systems. Consumers are largely unaware of standards and quality assurance for solar.

- **Perceptions of households vary according to experience they have had with solar**

  - Although many households recognize the benefits of solar, there is a general perception that solar equipment is very expensive and that products are considered largely un-affordable.
  - Many customers are disappointed with solar technology or mistrust it because:
    - They have bought a substandard/not certified product that broke down quickly;
    - There was no adequate maintenance, aftersales service when the system broke down;
    - There was lack of understanding/experience on how to use the system and it broke down due to over usage or incorrect usage.
    - There is no warranty or fault management system (long-term O&M)
  - Households that have a fuel-powered generator, consider them as a 'sunk cost' and treat solar only as an addition to that cost.
  - Solar is seen as risky by many. Since there are so many options and little information as to what the best solution is, many people think that it is easy to make a costly mistake in choosing what is

[120] Focus group participants indicated that Western and Central regions exhibit lower levels of awareness of solar solutions, while other regions (namely Upper East, Upper West, Northern, Brong Ahafo, Ashanti, Greater Accra, Volta and Eastern Region) have much higher / almost universal awareness of OGS products.

best for them. Generators are much better understood.
- Some consumers have 'investment fatigue' from buying multiple solar products of low or unknown quality and are unwilling to make further investments.

➢ **Willingness to Pay is strongly associated with consumer understanding and perceptions of OGS**

Although there is demonstrated ability to pay for households in higher income demographics on cash purchase, and for many households through a financed scenario, willingness to pay is strongly associated with consumer understanding and perceptions of OGS. Component-based Plug-and-Play SHS are much more expensive than battery-powered alternatives and are more than what households expect to pay for access to lighting. Consumers who purchase low-priced inferior lighting products for which they have low expectations are less likely to be willing to purchase a relatively high priced OGS system without fully understanding the difference between the products.

Since most of the retail-shop dry-cell battery-powered lighting products are extremely low cost (and short-lived), conservative rural consumers are wary of expensive new products if they are unable to assess product quality and durability. For this reason, willingness to pay presents a much larger barrier for the development of sales than actual *ability* to pay. East African experience with Global Lighting-certified products has demonstrated that consumer awareness campaigns can grow the demand for quality products.

2.2 Demand – Institutional

2.2.1 Overview of Institutional Market Segment

This section estimates the market potential for off-grid solar products for institutional users in Ghana. This market includes the following segments: (i) rural water supply, (ii) healthcare facilities, (iii) primary and secondary schools, and (iv) public town center lighting. The following sub-sections provide an overview of the assumptions used for each market segment along with corresponding analysis. The section concludes with an assessment of institutional ability to pay, looking at funding sources and highest potential market segments. **Annex 2** provides an overview of the methodology, including all calculations.

2.2.2 Analysis of Institutional Market Segment Demand

Table 18 shows the total estimated annualized cash market potential for institutional users in Ghana. This estimation is calculated using GIS data, secondary research, and primary source field data. The analysis is based on available information from planned expansion of the sectors and typical usage patterns and costs of existing systems in the country.

Table 18: Indicative Total Cash Market Potential for Institutional Sector[121]

Institutional Sector		Units	kW Equivalent	Cash Value (USD)
Water supply	Low power pumping system	226	339	$848,625
	Medium power pumping system	222	887	$2,217,000
	High power pumping system	106	1,063	$2,656,250
	Subtotal	554	2,289	$5,721,875
Healthcare	Health post (HC1)	179	45	$111,875
	Basic healthcare facility (HC2)	60	90	$224,438
	Enhanced healthcare facility (HC3)	13	54	$134,400
	Subtotal	252	189	$470,713
Education	Primary schools	76	38	$114,450
	Secondary schools	7	14	$35,040
	Subtotal	83	52	$149,490
Public lighting	Public lighting (excluding street lighting)	109	55	$164,100
TOTAL		**998**	**2,585**	**$6,506,178**

Source: African Solar Designs analysis

[121] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

- **Water Supply**

Table 19: Key Assumptions for Water Supply Sector Analysis

Sector	System Sizes	Key Assumptions
Water supply	• Low Power (1,500 W) • Medium Power (4,000 W) • High Power (10,000 W)	The type of pump selected is dependent on depth, yield, community need and other factors. System sizes depend on the common pump sizes used for rural applications: • Low power pumps are used for low/medium head applications. They replace hand pumps for shallow wells • Medium power pumps have high volume low head and medium volume medium head applications • High power pumps are used for high volume or high head applications such as deep wells and boreholes

The water supply sector analysis considered the electricity needs for water supply for communities in off-grid areas. Energy is only one component of this sector – a variety of factors (water quality, number of users, yields of well, delivery system etc.) need to be considered when planning for off-grid water supply. The supply of solar powered pumping systems for village water supply requires additional planning and study to identify the most viable sites.

Available GIS data identified off-grid water points such as boreholes and wells that could be electrified by stand-alone systems. Based on the analysis, the estimated annualized cash market potential for the water supply sector is presented in **Table 20**.[122] The distribution of off-grid water points is presented in **Table 21** and in **Figures 28-29**.

Table 20: Estimated Cash Market Potential for Water Supply[123]

Pump Type	Units	Size (kW)	Cash Value (USD)
Low power	226	339	$848,625
Medium power	222	887	$2,217,000
High power	106	1,063	$2,656,250
Total	**554**	**2,289**	**$5,721,875**

Source: African Solar Designs analysis

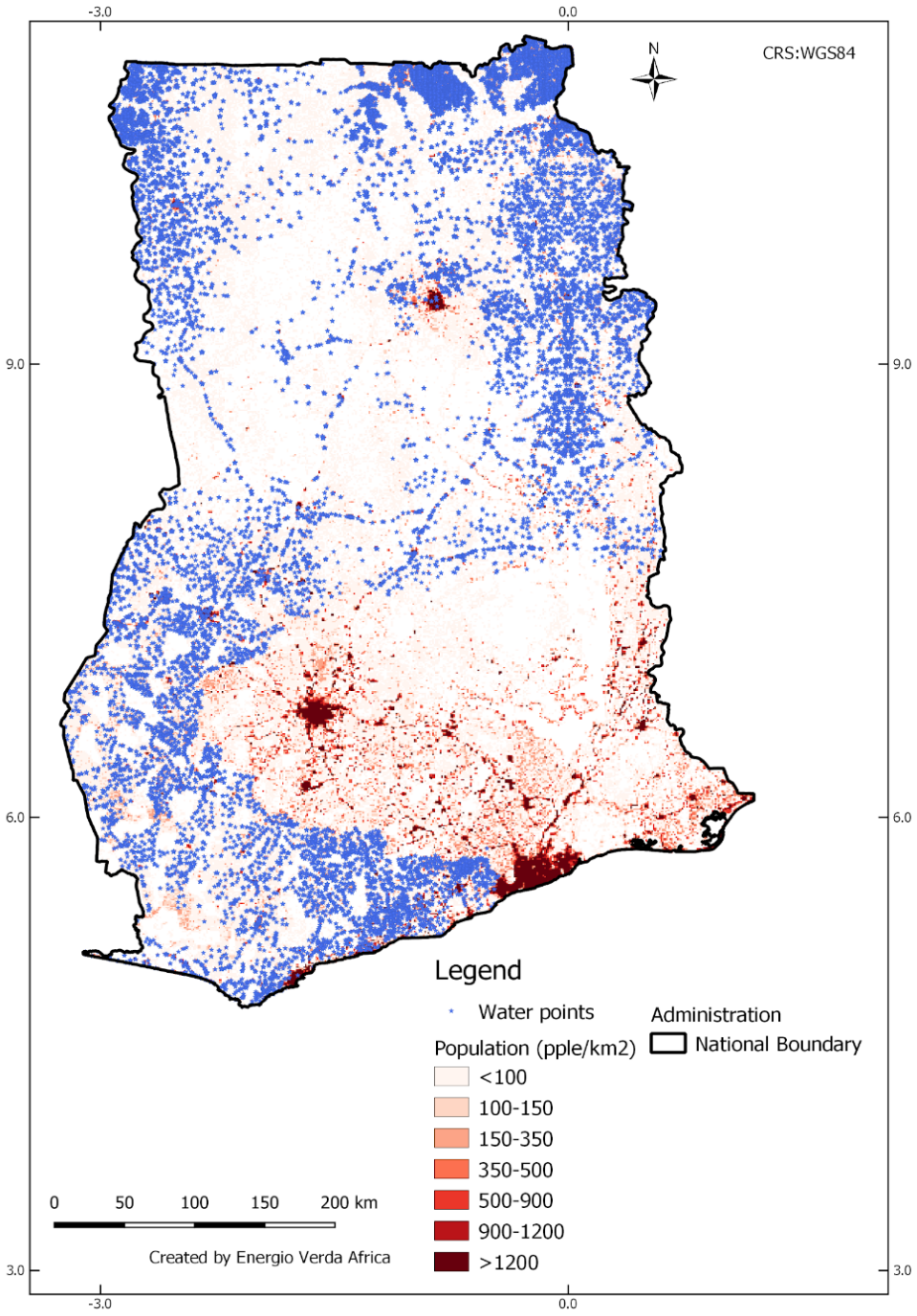
Table 21: Distribution of Water Points by Region[124]

Water Source	Brong Ahafo	Central	Northern	Upper East	Upper West	Western	Total
Borehole	3,244	1,867	6,915	4,515	2,538	1,429	20,508
Hand dug well	120	228	473	524	111	486	1,942
Natural spring		1					1
Spring water	1						1
Total	**3,365**	**2,096**	**7,388**	**5,039**	**2,649**	**1,915**	**22,452**

Source: World Vision; Energio Verda Africa analysis

[122] See **Annex 2** for more details.
[123] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[124] World Vision water study, Ghana, (2017): https://www.worldvision.org/our-work/country-profiles/ghana

Figure 28: Distribution of Water Points and Population Density

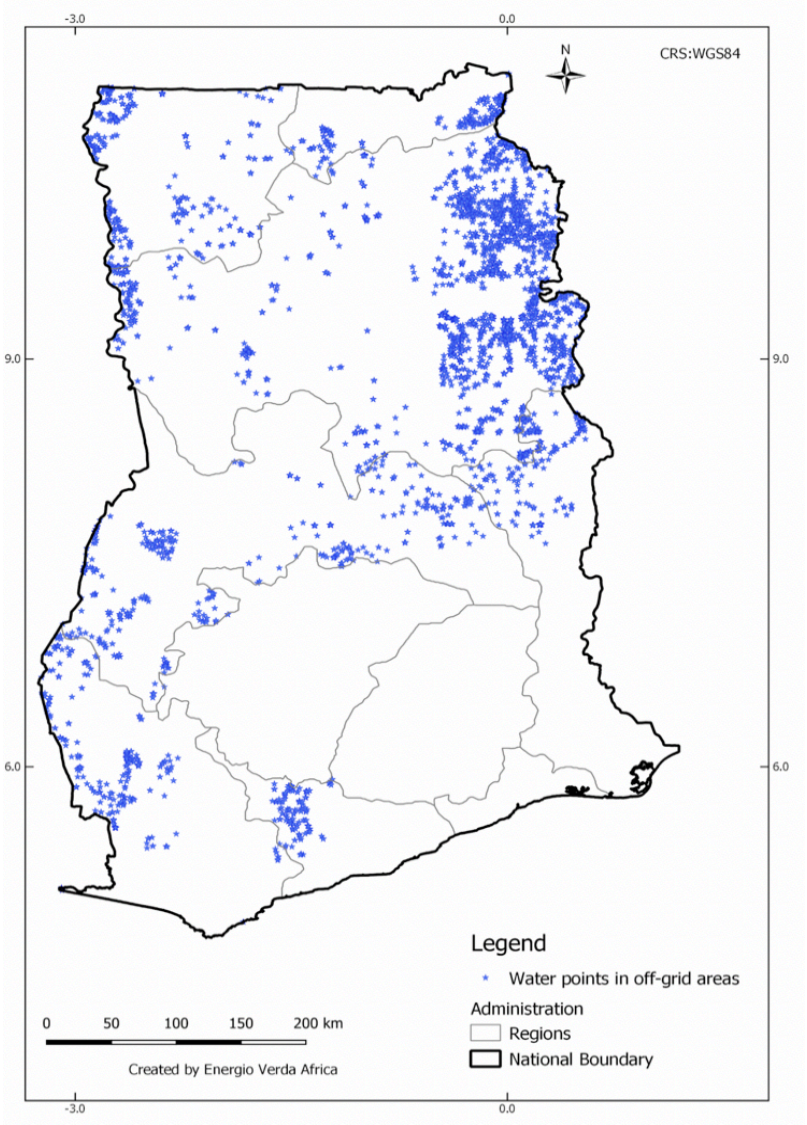


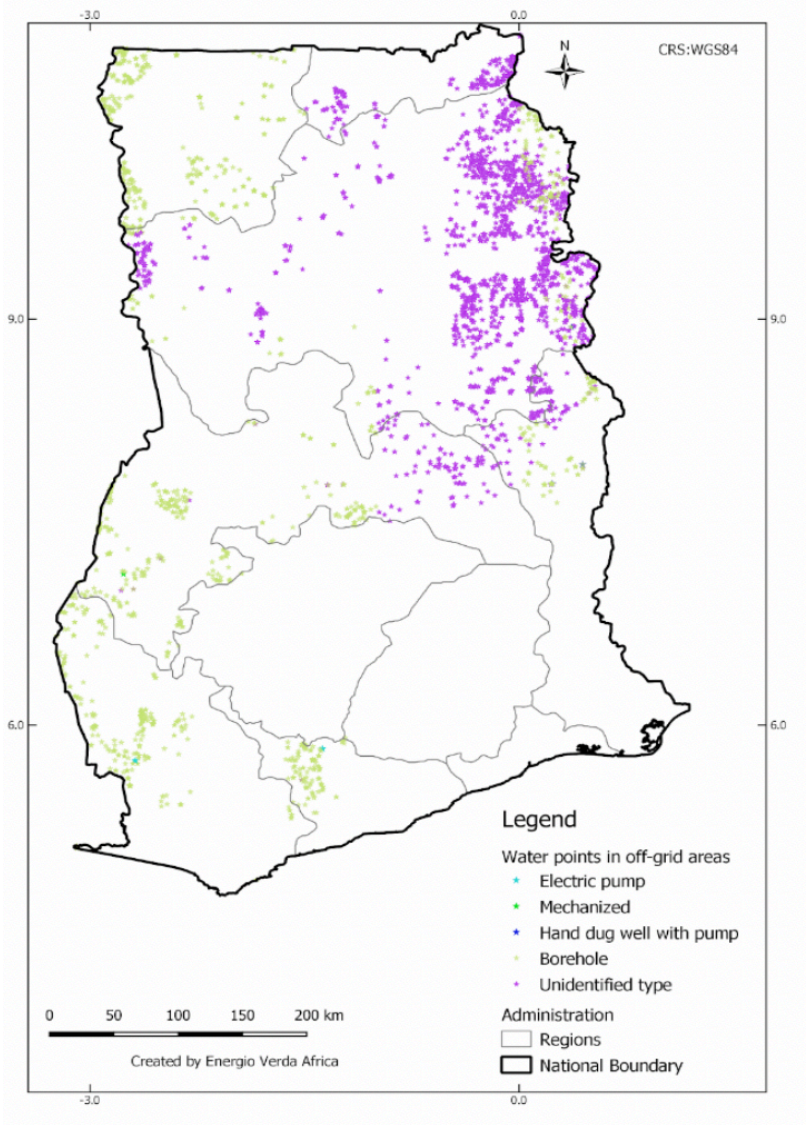
Source: Columbia University CIESIN [population][125] and Community Water and Sanitation Agency [water points][126] Energio Verda Africa GIS analysis

[125] Facebook Connectivity Lab and Center for International Earth Science Information Network – CIESIN – Columbia University, 2016. High Resolution Settlement Layer (HRSL). Source imagery for HRSL © 2016 DigitalGlobe

[126] https://cwsawateratlas.org

Figure 29: Distribution of Water Points in Off-Grid Areas





Source: Community Water and Sanitation Agency; Energio Verda Africa GIS analysis

- **Healthcare**

Table 22: Key Assumptions for Healthcare Sector Analysis

Sector	System Sizes	Key Assumptions
Healthcare	• HC1: Dispensary health post (300 W) • HC2: Basic healthcare facility (1,500 W) • HC3: Enhanced healthcare facility (4,200 W)	2,348 off-grid healthcare facilities were identified that could be electrified by stand-alone systems

The healthcare sector analysis considered the electricity needs for off-grid health facilities in the country. Off-grid clinics require power for lighting and various Information and Communications Technology (ICT) needs, including phone charging, maternity, medical examinations, vaccine refrigeration, laboratory, sterilization and staff housing. The size of a facility and number of patients served determines the amount of energy it requires.

Available GIS data identified off-grid health facilities categorized according to their size (HC1, HC2, and HC3) that could be electrified by stand-alone systems.[127] To establish electricity demand, an assessment of equipment found within each category of healthcare facility was undertaken, with the daily demand of each used to calculate the system size required to cater to the load of the facility (**Table 23**). The assumptions of system size below are based on the services offered at each of these facilities.

Table 23: Healthcare Facility Categorization and Electricity Demand[128]

Type of Facility	Load Category	Wh/day	Total Load (Wh/day)	System Size (W)
Health post (HC1)	Lighting	240		
	Communication	160		
	ICT	800		
			1,200	**250**
Basic healthcare facility (HC2)	Lighting	1,600		
	Maternity	800		
	Vaccine refrigeration	800		
	Communication	400		
	Examination room	400		
	ICT	1,600		
	Staff housing	400		
			6,000	**1,500**
Enhanced healthcare facility (HC3)	Lighting	3,200		
	Communication	1,600		
	Examination room	1,200		
	ICT	2,400		
	Maternity	2,400		
	Laboratory	2,000		
	Sterilization	1,200		
	Vaccine refrigeration	1,200		
	Staff housing	1,600		
			16,800	**4,200**

Source: GIZ; African Solar Designs analysis

[127] NOTE: This represents a small subset of the overall health infrastructure in the country; See **Annex 1** for more details.
[128] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf

Based on these assumptions, the estimated annualized cash market potential for healthcare facilities is presented in **Table 24**. The distribution of potential off-grid health facilities is shown in **Figures 28-29**.

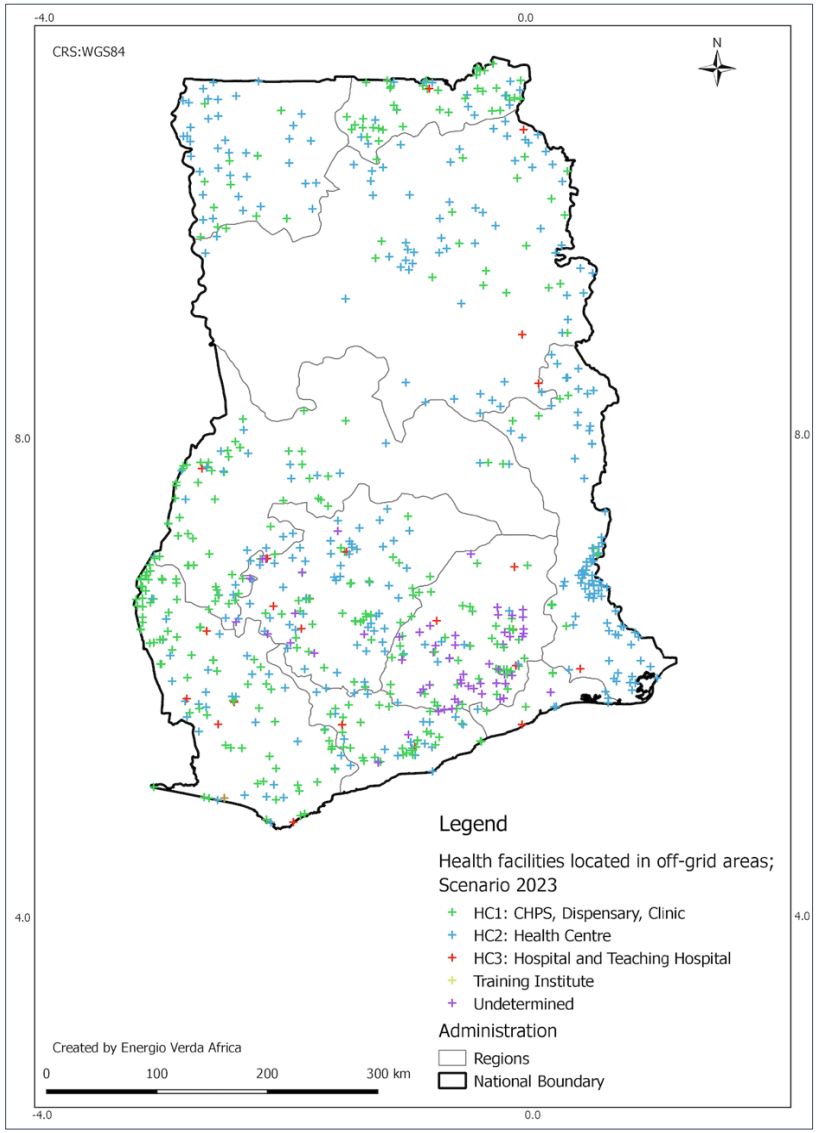
Table 24: Estimated Cash Market Potential for Healthcare Facilities[129]

Type of Facility	Units	kW Equivalent	Cash value (USD)
Health post (HC1)	179	45	$111,875
Basic healthcare facility (HC2)	60	90	$224,438
Enhanced healthcare facility (HC3)	13	54	$134,400
Total	**252**	**189**	**$470,713**

Source: African Solar Designs analysis

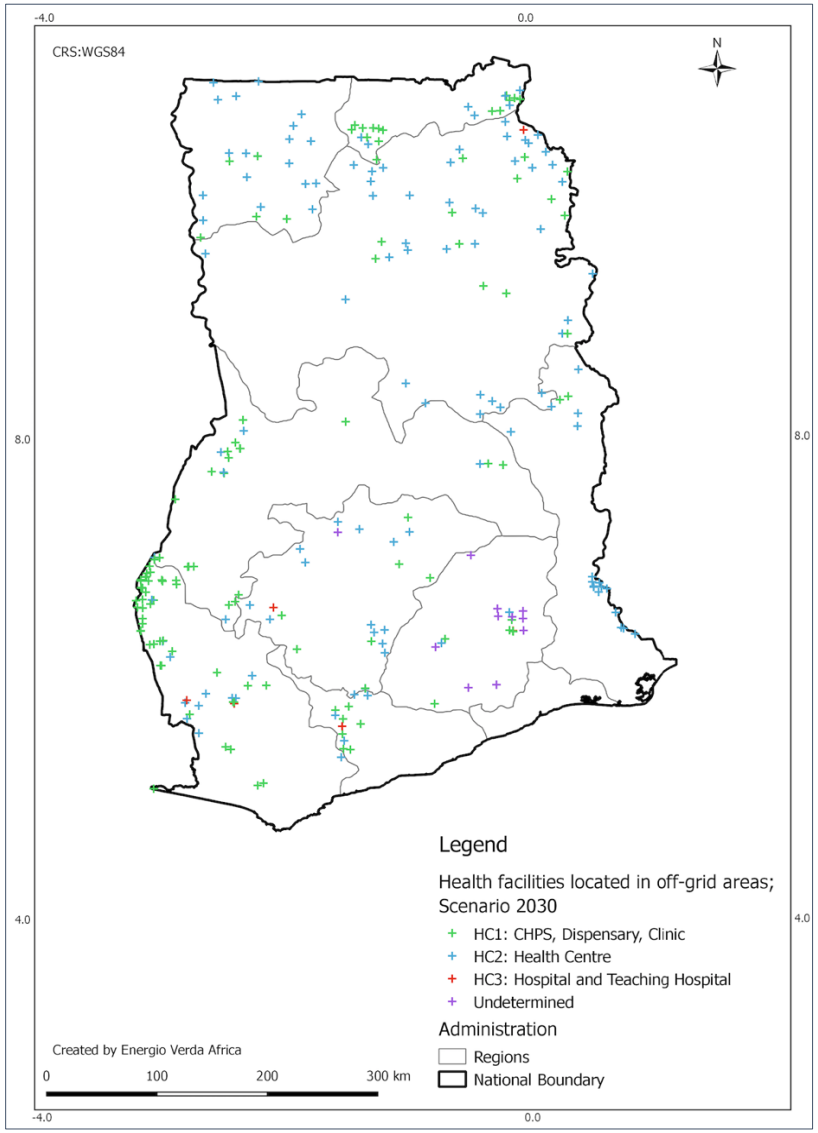
[129] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 30: Distribution of Potential Off-Grid Health Facilities, 2023



Source: Energio Verda Africa GIS analysis

Figure 31: Distribution of Potential Off-Grid Health Facilities, 2030



Source: Energio Verda Africa GIS analysis

- **Education**

Table 25: Key Assumptions for Education Sector Analysis[130]

Sector	System Sizes	Key Assumptions
Education	• Elementary schools (500 W) • Secondary schools (1,920 W)	1,526 off-grid primary schools and 146 off-grid secondary schools were identified that could be electrified by stand-alone systems

The education sector analysis considered the electricity needs of off-grid primary and secondary schools.[131] These include lighting, ICT (computers, tablets etc.), communication (phone charging), laboratories and staff housing. The size of a school and number of students determines the amount of energy it requires. Available GIS data identified off-grid primary and secondary schools that could be electrified by stand-alone systems. To establish electricity demand, an assessment of equipment found within each type of school was undertaken, with the daily demand of each used to calculate the system size required to cater to the load of the school (**Table 26**).

Table 26: Education Center Categorization and Electricity Demand[132]

Type of Facility	Load Category	Wh/day	Total Load (Wh/day)	System Size (W)
Primary School	Communication	160		
	Lighting	640		
	ICT	800		
	Staff house	400		
			2,000	**500**
Secondary School	Communication	160		
	Lighting	1,920		
	ICT	3,200		
	Laboratory use	800		
	Staff house	1,600		
			7,680	**1,920**

Source: GIZ; African Solar Designs analysis

Based on these assumptions, the estimated annualized cash market potential for the education sector is presented in **Table 27**. The distribution of potential off-grid primary and secondary schools is shown in **Figures 32-33**.

Table 27: Estimated Cash Market Potential for Primary and Secondary Schools[133]

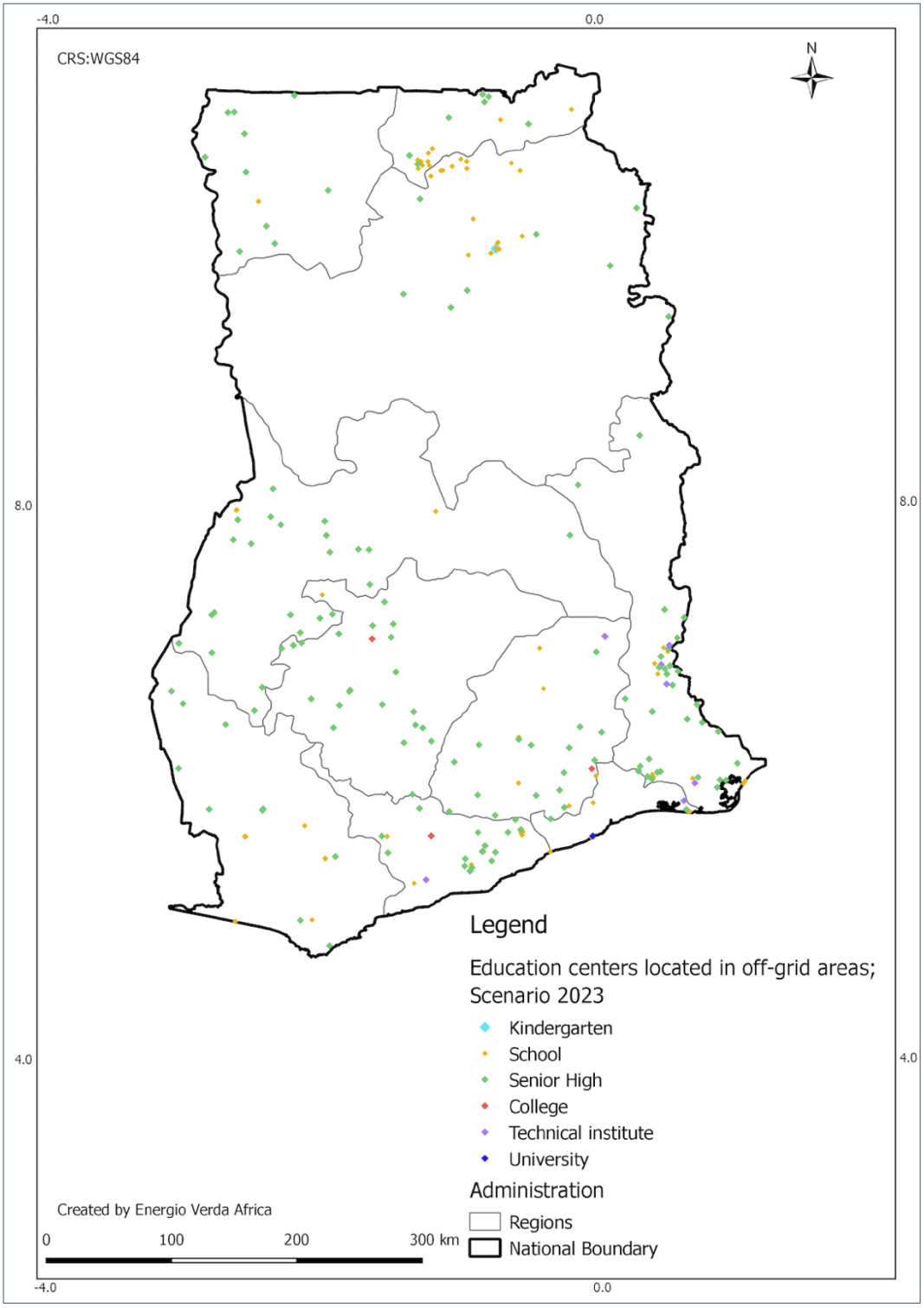
Type of Facility	Units	kW Equivalent	Cash value (USD)
Primary School	76	38	$114,450
Secondary School	7	14	$35,040
Total	**83**	**52**	**$149,490**

Source: African Solar Designs analysis

Focus group participants indicated that several of off-grid schools located in the Eastern region are electrified by rooftop solar panels. However, some of these schools lack the funds necessary to replace solar batteries. Others explain that systems installed in some off-grid communities had been vandalized or stolen. In general, there is a feeling that a framework is needed to properly manage OGS electrification of schools.

[130] NOTE: While the GIS analysis in **Section 1.2.2.4** covers all education centers (including nursery, pre-primary, primary, secondary, technical-vocational, universities etc.), this analysis only examines primary and secondary schools (see **Annex 1** and **Annex 2**).
[131] Primary schools encompass both primary and nursery schools. Vocational schools and universities were not considered because they tend to be in cities, which are often grid electrified.
[132] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf
[133] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

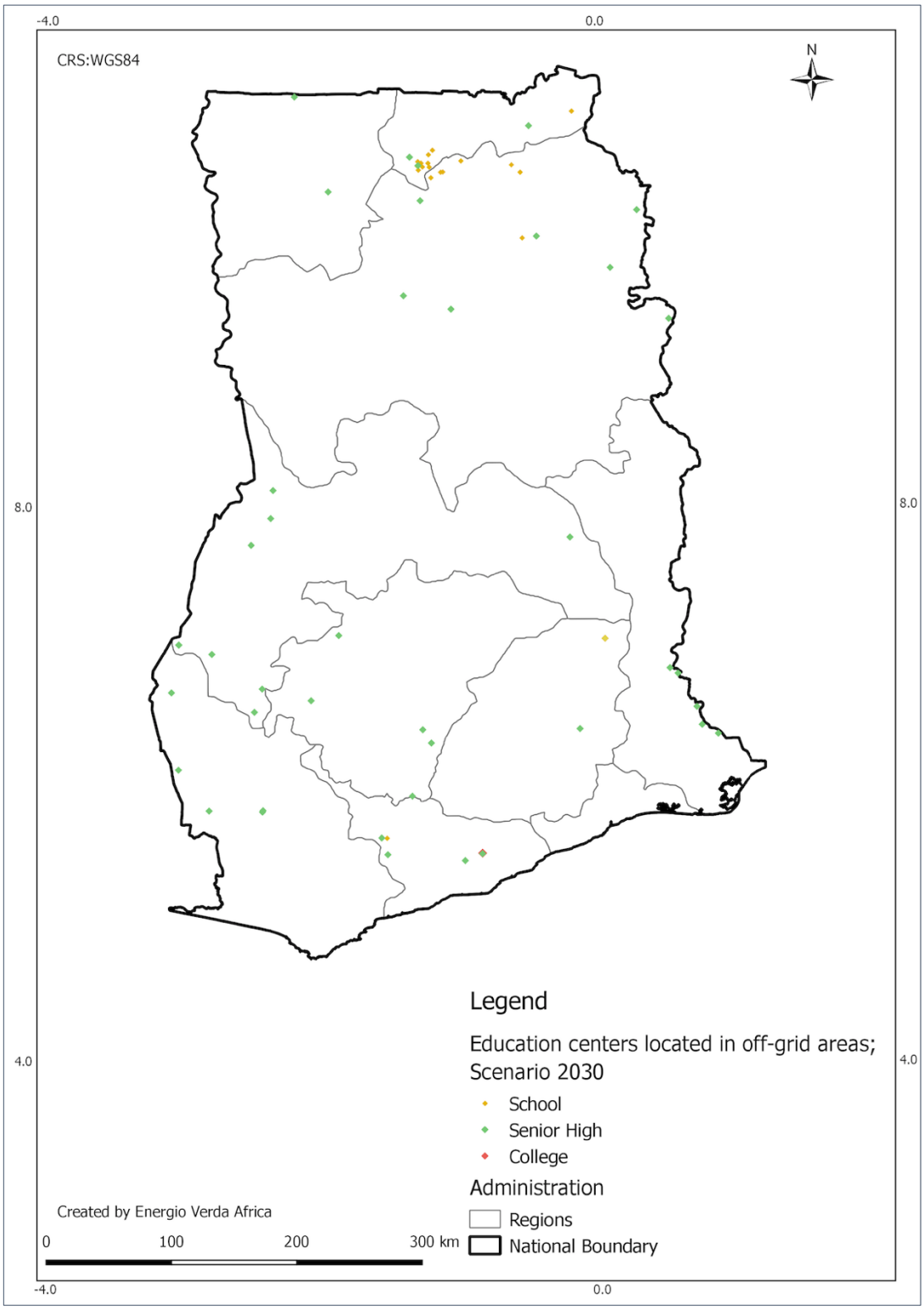
Figure 32: Distribution of Potential Off-Grid Primary and Secondary Schools, 2023[134]



Source: Energio Verda Africa GIS analysis

[134] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

Figure 33: Distribution of Potential Off-Grid Primary and Secondary Schools, 2030[135]



Source: Energio Verda Africa GIS analysis

[135] Displaying identified facilities with known location (given coordinates) only; see **Annex 1** for more details, including data sources.

- **Public Lighting**

Table 28: Key Assumptions for Public Lighting Sector Analysis[136]

Sector	System Sizes	Key Assumptions
Public lighting	Standard system (200 W)	• District population figures were used to determine the number of market centers per district, assuming 5,000 people per market center • Each market center was assumed to have two public lighting points

Analysis of the public lighting sector considered the public lighting needs for off-grid villages and market centers. It did not assess public street lighting, which would generally be included in road infrastructure projects. Based on these assumptions, the estimated annualized cash market potential for the public lighting sector is presented in **Table 29**.

Table 29: Estimated Cash Market Potential for Public Lighting[137]

Public Lighting Network	Units	kW Equivalent	Cash value (USD)
Village lighting (excluding street lighting)	109	55	$164,100

Source: African Solar Designs analysis

2.2.3 Ability to Pay and Access to Finance

Financing for institutional off-grid systems in Ghana typically comes from budget allocations made directly by relevant ministries or, more commonly, by donor-funded projects. In recent years, virtually all institutional solar projects in the country have been financed with tender-based procurements and cash-based contracts. Government allocations are typically made ad-hoc, depending on the needs and priorities of the ministry, and whether funds are available. Operation, maintenance and replacement of parts in energy systems (e.g. solar system batteries and inverters) is typically the responsibility of the institution and community. Schools, clinics and other institutions with generators must buy fuel on a regular basis. With the development of the renewable energy sector, NGO/donor funds increasingly design projects that ensure that maintenance of the system is factored into its implementation. However, when there are no funds to maintain the system any further, usage is typically discontinued, and the system falls into disrepair.

Institutional users that rely on government or donor funds for the purchase and O&M of solar systems may be constrained by limited funds and/or competing budget priorities. Thus, local communities benefiting from solar electrification would also have to bear some long-term costs for the maintenance of systems and replacement of parts. In the event that public or donor funding is made available to cover the initial capital expenditure, funds can be raised by local communities through a minimal tariff to customers of the health facilities, water pumping stations etc. for long-term O&M. A market standard of 5-10% of the capital expenditure is accepted as a rate for annual maintenance of systems.[138]

Given budgetary constraints, some institutional sectors may be prioritized for solar electrification over others. Advanced health centers for example, could be prioritized by governments and communities given that electricity is essential to run advanced healthcare equipment. It may be easier in this case to extract maintenance fees from community members receiving health services or budget allocations from local government. In contrast, off-grid schools can be run more easily without access to electricity and may therefore present a lower priority institutional market.

[136] Population figures used in this analysis were obtained from: https://www.citypopulation.de/Ghana-Cities.html
[137] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[138] Grundfos: https://www.grundfos.com/service-support/encyclopedia-search/maintenance-and-repaircostscm.html

2.3 Demand – Productive Use

2.3.1 Overview of Productive Use Market Segment

The section provides an overview of the main characteristics of productive use of energy (PUE) and how off-grid solar applications have the potential to generate economic activity, increase productivity and transform rural livelihoods in Ghana. Focus group participants noted that productive use applications in the agricultural, food processing and informal sectors already exist in the country, including solar powered lighting, mobile phone charging, refrigeration and chilling, water pumping, irrigation and agricultural processing. The PUE market sizing analyzed demand for SME applications for village microenterprises, value-added applications for solar powered irrigation, milling and refrigeration, and connectivity applications for mobile phone charging enterprises.

The calculation of the estimated off-grid solar market for SMEs focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit significantly from extended working hours and the use of modern appliances/machinery. The estimated demand for this market segment is therefore intended to provide a baseline for future research, as a more robust analysis would be necessary to assess realistic demand from all SMEs.

The value-added applications that were analyzed include solar pumping for smallholder agricultural irrigation, solar powered milling and solar refrigeration. Access to energy for agriculture is critical to economic development, particularly given the sector's importance to GDP in the country.

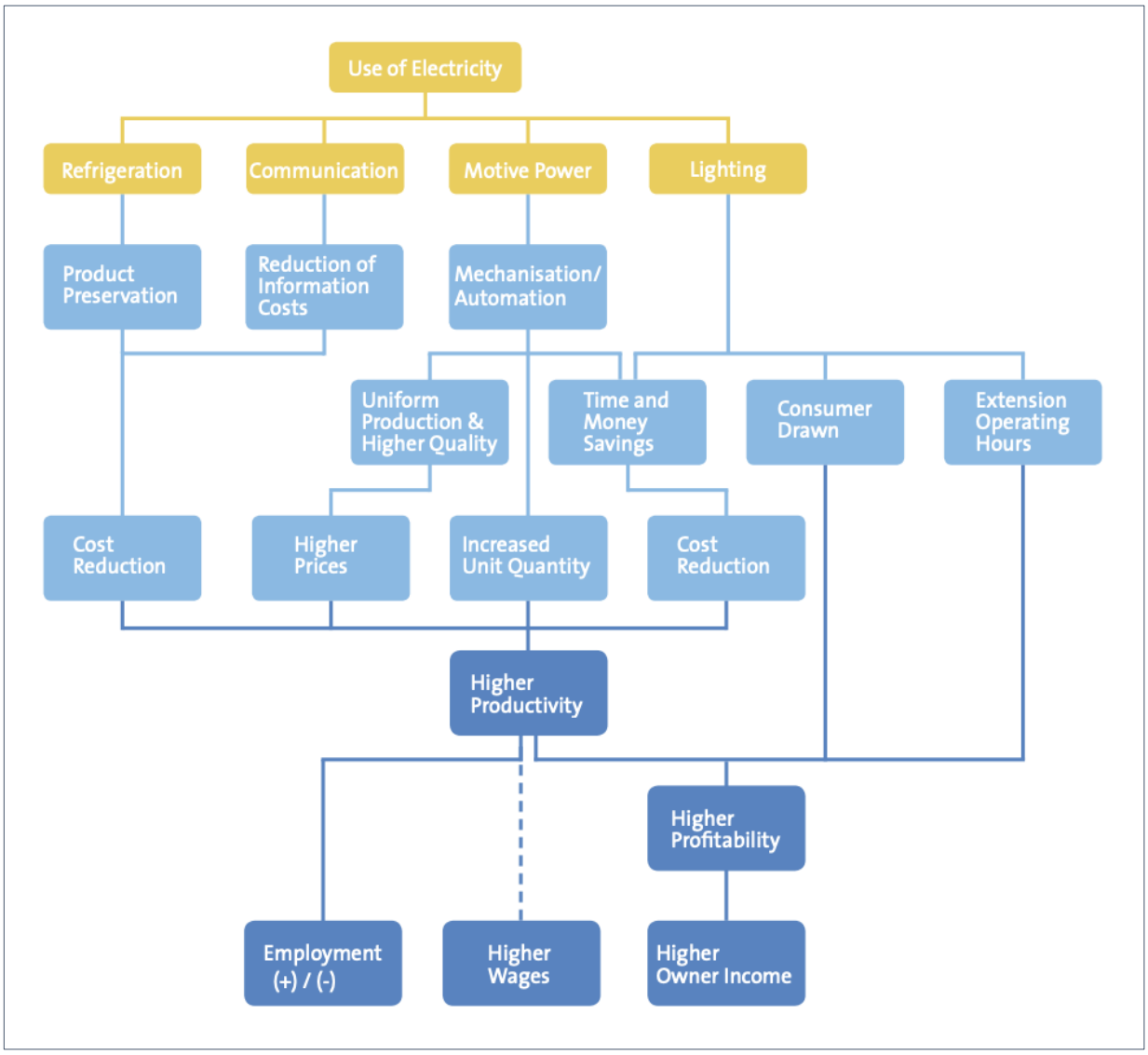
Off-grid solar power supports a wide range of connectivity applications, including mobile phone charging, wi-fi servers, banks, mobile money kiosks, and telecommunications towers. Mobile phone and internet connectivity are also necessary precursors for mobile money and PAYG solutions in the off-grid solar sector. The market sizing examined rates of mobile phone ownership and mobile internet penetration to estimate the market potential for mobile phone charging enterprises (stations/kiosks) in the country.

Given that the services sector makes up 56.2% of Ghana's GDP,[139] lack of reliable power has had a negative impact on the profitability of firms. Nonetheless, stakeholder interviews highlighted the importance of solar appliances to the fishing and agricultural sectors. Furthermore, business owners in areas with widespread grid connections have also been forced to deploy off-grid solutions, usually fossil fuel powered generators, due to the unreliability of grid connected power (**Figure 3**).[140] There are also a number of productive use sub-sectors where solar power can immediately add value and build income. The impact of electricity use on SMEs depends on a variety of external and internal factors, especially access to markets, the location of the firm, supply of inputs and financial capability. Therefore, the extent to which firms can afford to invest in off-grid solar solutions is determined largely by increases in productivity, profitability, and employment/wages from the investment in the off-grid appliance (**Figure 34**).

[139] "Provisional 2017 Annual Gross Domestic Product," Ghana Statistical Service (April 2018): http://www.statsghana.gov.gh/docfiles/GDP/GDP2018/2017%20Quarter%204%20and%20annual%202017%20GDP%20publications/Annual_2017_GDP_April%202018%20Edition.pdf

[140] Ghanaian firms surveyed had an average of 8.4 power outages a month, refer to World Bank, Enterprise Surveys: http://www.enterprisesurveys.org/.

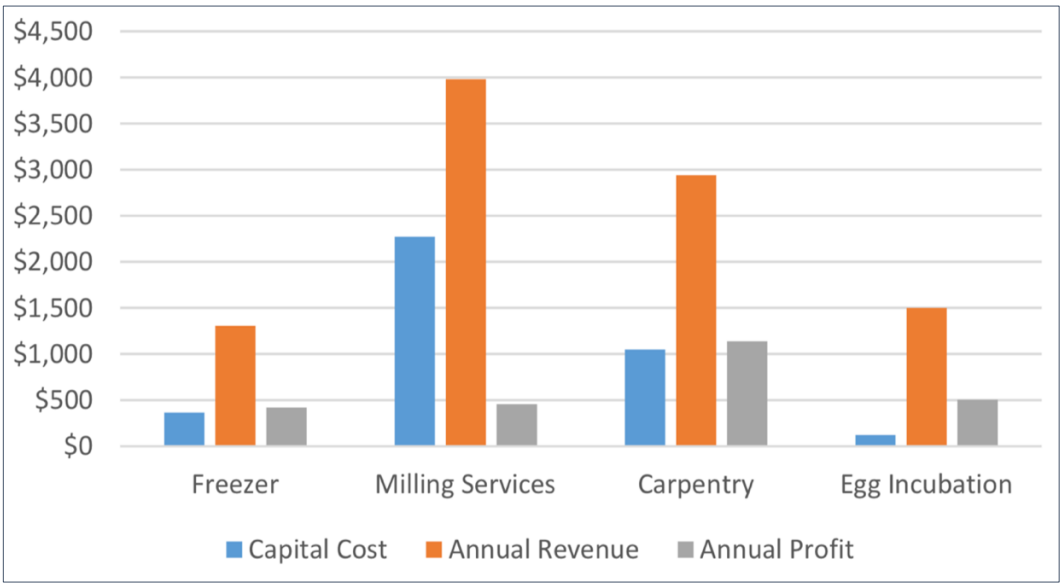
Figure 34: Pathways from Electricity to Income Generation[141]



Source: EUEI PDF and GIZ: Productive Use of Energy – A Manual for Electrification Practitioners

[141] Productive Use of Energy – A Manual for Electrification Practitioners," European Union Energy Initiative Partnership Dialogue Facility (EUEI PDF) and GIZ, (2011): https://www.giz.de/fachexpertise/downloads/giz-eueipdf-en-productive-use-manual.pdf

Figure 35: Analysis of Cost, Revenue and Profit for Various Off-Grid Productive Use Applications[142]



NOTE: Annual profit does not include recovery of cost capital

Source: USAID-NREL and Energy 4 Impact: Productive Use of Energy in African Microgrids

In order to organize and simplify this analysis and to deliver meaningful insights on country-level market sizing, productive solar applications have been divided into three main groups (**Table 30**).

Table 30: Overview of Productive Use Applications

Productive Use Application	Description
1) SME applications for village businesses	SME applications include barber shops and tailors. While these businesses employ people and are critical for off-grid towns, they do not create additional income for towns and are not transformative in nature. Therefore, SME businesses are most at risk during economic downturns because they are at the mercy of the overall economic and political climate.
2) Value-added applications	Value-added productive use applications enable businesses to add value to products or services and to build new income streams. This can be done by creating a new product or service or by enhancing the value of an existing product (e.g. milling maize). Water pumping tools that support the agricultural, dairy or fishing value chains are included here (water pumps, refrigerators/chillers, and grain mills).
3) Connectivity / ICT applications	Connectivity applications enable consumers to communicate and access data from the internet. Following the advent of mobile phones and mobile money in East Africa, solar devices that support connectivity applications became the most important income earning applications in East Africa. Mobile phone charging is extremely important for the telecommunications sector. Other connectivity applications include wi-fi servers, mobile money kiosks, banks, and telecommunications towers.

Source: African Solar Designs

[142] "Productive Use of Energy in African Micro-Grids: Technical and Business Considerations," USAID-NREL and Energy 4 Impact, (August 2018): https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/productive_use_of_energy_in_african_micro-grids.pdf

- **Geographic Locations**

Most PUE sector activities will take place in rural off-grid towns in Ghana. In order to address energy access and reliability issues, the Government and donor community have taken notable action.[143] Given the country's relatively high electrification rate, off-grid policy initiatives have focused mainly on rural communities residing in small island communities in Lake Volta.[144]

2.3.2 Analysis of Productive Use Market Segment Demand

Data from the World Bank, Food and Agriculture Organization of the UN (FAO) and GSMA was used to conduct the PUE market study. In order to conduct the analysis, several key assumptions were made about PUE applications, which are presented in the sections below and in **Annex 2** in greater detail. **Table 32** presents the estimated annualized cash market potential for off-grid solar productive use applications.

Table 31 presents the estimated total cash market potential for the productive use sector in Ghana.

Table 31: Indicative Total Cash Market Potential for Productive Use Sector[145]

Productive Use Sector		Units	kW Equivalent	Cash Value (USD)
SME Applications for Village Businesses	Microenterprises	1,127	282	$704,500
Value-added Applications	Irrigation	263,889	31,667	$171,527,778
	Milling	1,057	6,868	$17,170,058
	Refrigeration	109	602	$1,504,250
	Subtotal	265,055	39,137	$190,202,086
Connectivity Applications	Phone Charging	17,381	6,952	$14,982,022
TOTAL		**283,563**	**46,371**	**$205,888,608**

Source: Food and Agriculture Organization, GIZ and GSMA; African Solar Designs analysis

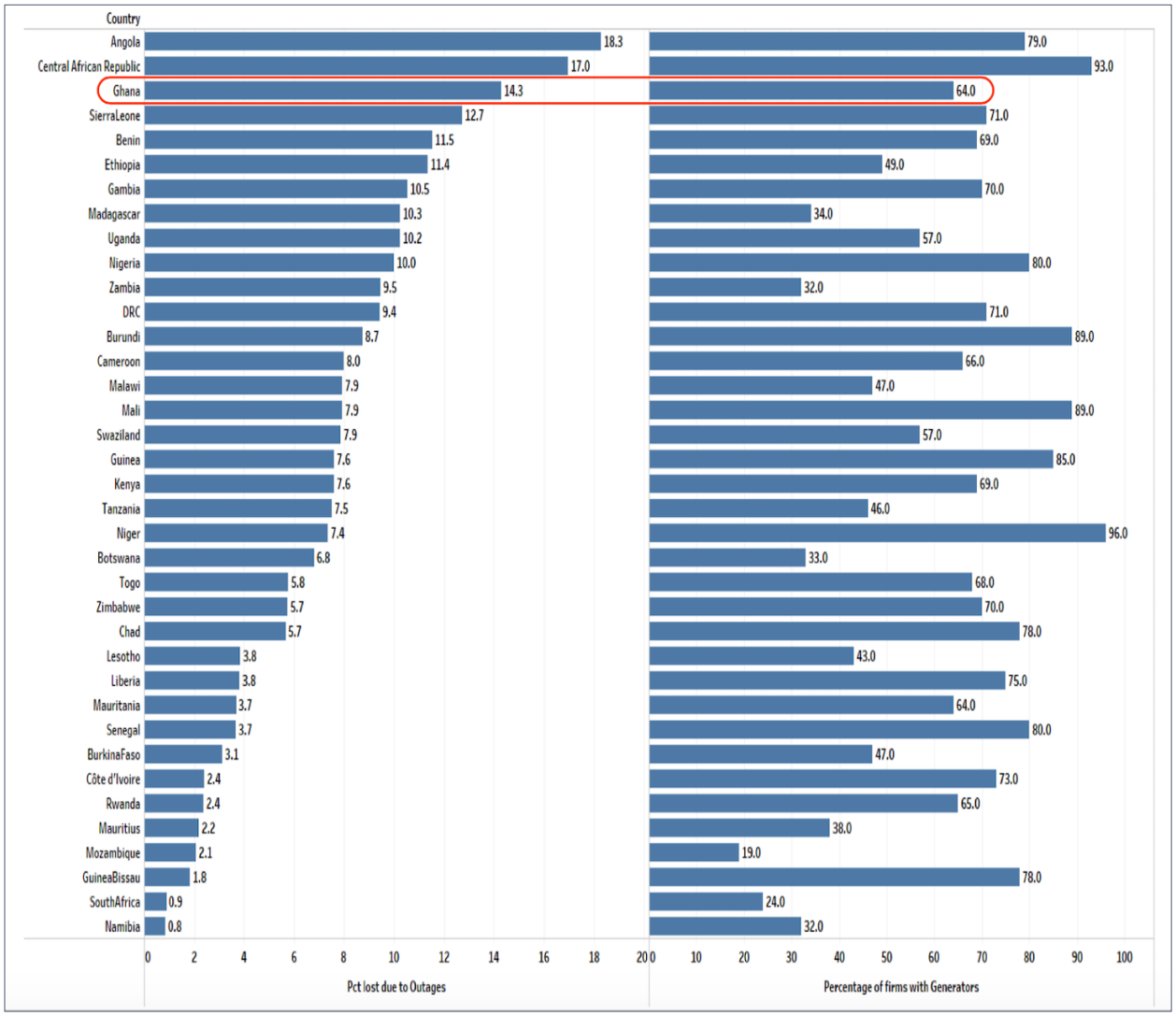
- **SME Applications for Village Businesses**

Access to solar powered appliances can have a wide-ranging impact on SMEs, many of which would otherwise rely on diesel- or petrol-powered generators to power their enterprises. Close to 33% of SMEs in emerging markets use fossil fuel powered generators in order to address energy insecurity.[146] For ECOWAS countries, independent power generation via fossil fuel powered generators is especially prevalent.[147]

Access to reliable electricity has become a significant impediment for SME growth in Ghana – SMEs in the country have lost an estimated USD 686.4 million in sales annually since 2009 due to higher energy bills and investment in alternative power supply.[148] Power outages account for an estimated 14.3% of annual sales losses; accordingly, unreliable electricity supply has resulted in 64% of Ghanaian firms owning generators (**Figure 36** and **Figure 37**).

[143] "Ghana Energy Sector Transformation Initiative Project," Project Appraisal Document, World Bank (2018): https://www.worldbank.org/en/news/loans-credits/2018/07/13/ghana-energy-sector-transformation-initiative-project
[144] "Island Communities in Ghana get electricity," World Bank (2017): http://blogs.worldbank.org/nasikiliza/island-communities-in-ghana-get-electricity-at-last.
[145] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[146] Foster, V., and Steinbuks, J., "Paying the Price for Unreliable Power Supplies: In-House Generation of Electricity by Firms in Africa," World Bank Policy Research Working Paper, (2009): https://openknowledge.worldbank.org/handle/10986/4116
[147] Ibid.
[148] Forkuoh, S., Li, Y., "Electricity Power Insecurity and SMEs Growth: A Case Study of the Cold Store Operators in the Asafo Market Area of the Kumasi Metro in Ghana," Open Journal of Business and Management (2015).

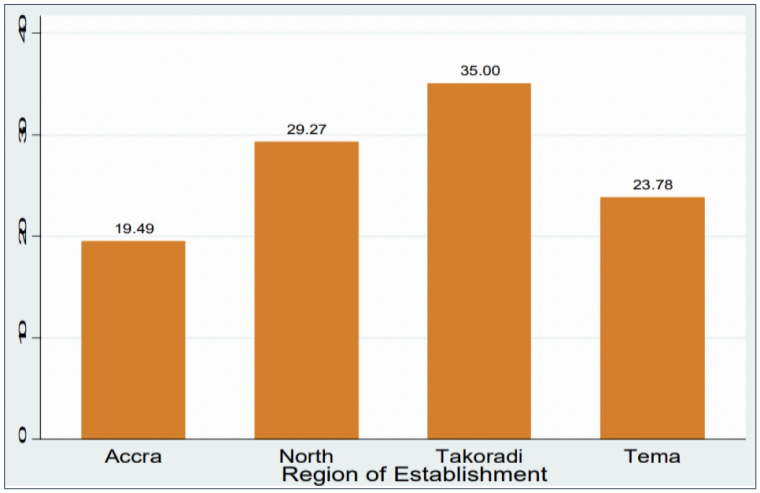
Figure 36: Percentage of Sales Lost due to Power Outages and Percentage of Firm with Generator[149]



Source: Center for Global Development

[149] Ramachandran, V., Shah, M. K., Moss, T., "How Do African Firms Respond to Unreliable Power? Exploring Firm Heterogeneity Using K-Means Clustering," Center for Global Development, (August 2018): https://www.cgdev.org/sites/default/files/how-do-african-firms-respond-unreliable-power-exploring-firm-heterogeneity-using-k-means.pdf

Figure 37: Percentage of Firms Self-Generating Electricity by Region, 2013[150]



Source: University of Cape Coast, Department of Economics

While many rural microenterprises would benefit from access to solar power, it may not be a requirement for a commercial enterprise to have access to electrical appliances. Further, while petit trade is facilitated greatly by the availability of electricity (kiosks and retail shops can be open longer hours and sell more and fresher products), electricity is not essential for SMEs because even without lighting, small shops can still sell their merchandise. Additionally, unlike value-added applications, there is not as strong a correlation between the value of the electric appliance and the economic capability of the SME. For example, a refrigerator used to preserve perishable food and chill beverages, irrespective of the value of food and beverages, may be used by either a large hotel or a street side vendor.

With the exception of replacing diesel gensets, the estimation of the available market for off-grid solar appliances for SMEs is not as closely correlated with economic indicators. Nonetheless, some widely marketed solar powered appliances are more centrally related to the revenue generation of SMEs. Investments in such appliances in off-grid and low-income settings are more likely to be sustainable. This study analyzed barbering and tailoring appliances (i.e. hair clippers and sewing machines designed or marketed for off-grid solar powered settings) with respect to microenterprises that face difficulty in accessing outside capital, as the two appliances would provide an economic opportunity for such entrepreneurs that are demographically most likely to be in off-grid communities. A study undertaken in West Africa that found little correlation between electricity access and a firm's profitability did, however, find that tailors do consistently benefit from electricity access.[151]

Focus group participants also highlighted the potential for solar power to support service-based industries, specifically those participating in retail sales of fish, meat, beverages, entertainment and phone charging. The calculation of the estimated OGS market focused only on barbering and tailoring appliances, which comprises a small portion of overall SME sector demand. These two microenterprises are indicative of the service-based SME off-grid solar market, as they benefit most from extended working hours and the use of modern appliances/machinery. The quantitative demand estimate for this market segment is therefore

[150] Nyanzu, F., Adarkwah. J., "Effect of Power Supply on the performance of Small and Medium Size Enterprises: A comparative analysis between SMEs in Tema and the Northern part of Ghana," University of Cape Coast, Department of Economics, (2016): https://mpra.ub.uni-muenchen.de/74196/1/MPRA_paper_74196.pdf

[151] Grimm, M., Harwig, R., Lay, J., "How much does Utility Access matter for the Performance of Micro and Small Enterprises?" World Bank (2012): http://siteresources.worldbank.org/INTLM/Resources/390041-1212776476091/5078455-1398787692813/9552655-1398787856039/Grimm-Hartwig-Lay-How_Much_Does_Utility_Access_Matter_for_the_Performance_of_MSE.pdf

intended to provide a baseline for future research, as a more robust analysis would be necessary to assess OGS demand from all SMEs.

According to the analysis, estimated annualized off-grid solar cash market potential for barbers and tailors is USD 704,500 (**Table 32**).

Table 32: Estimated Cash Market Potential for SMEs – Barbers and Tailors[152]

No. of SMEs with Constrained Access to Finance[153]	Units	kW Equivalent	Cash Value (USD)
5,636	1,127	282	$704,500

Source: World Bank; African Solar Designs Analysis

- **Value-Added Applications**

Agricultural practices, especially for smallholder farmers, can benefit from a wide range of off-grid solar technologies. Cold rooms and ice production are valuable investments for economies engaged in aquaculture. Solar refrigeration, cooling and processing equipment would enable traders and livestock farmers to sell dairy products. Solar drying of cocoa and palm oil processing are productive use applications that would greatly benefit rural farmers in the country (Ghana is among the largest producers/exporters of cocoa in the world).

The three value-added applications that were analyzed include solar pumping for agricultural irrigation, solar milling and solar powered refrigeration.

Solar Powered Irrigation:

In most West African countries, the national government is typically responsible for carrying out irrigation initiatives, which vary by the scale of the project and often require the construction of civil works such as dams, canals, embankments, and piping. Donor agencies and development partners provide funding for such projects. In Ghana, a variety of public sector donor institutions have provided substantial support toward furthering irrigation efforts (**Table 33**). This analysis focused instead on a small-scale private sector driven approach and estimated the market potential for off-grid solar pumping systems to support smallholder farmers.

Table 33: Major Donor-Funded Projects in Agriculture and Irrigation in Ghana[154]

Institution(s)	Commitment (USD million)	Type of Financing
World Bank (International Development Association)	100	Loan
Millennium Challenge Corporation	200	Grant
International Fund for Agricultural Development	78.5	Loan
United States Agency for International Development	45	Grant
African Development Bank	131.2	Loan/Grant
European Union, Organization of the Petroleum Exporting Countries Fund, and the Global Environment Facility	4.3	Loan/Grant

Source: Food and Agriculture Organization

[152] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[153] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap
[154] Ghana: Irrigation Market Brief, FAO: http://www.fao.org/3/a-i4158e.pdf

Solar pumping systems vary in their wattage depending on the area of land irrigated, the depth of water abstracted and the quality of the soil and crops among other factors.[155] GIS analysis demonstrated that access to the water table and surface water is not a major determinant of the costing of applicable solar irrigation systems, as most farming settlements in Ghana are within close proximity to either surface water or relatively easily extractable sources of water (**Figure 38**).

It is important to note that many Ghanaian farmers may be discouraged from making long-term irrigation investments on their land due to unclear land tenure rights because of competing claims with pastoralists, and the complexity of land laws that provide for customary and formal land rights.[156]

In analyzing the available market for solar-powered irrigation, this market scoping exercise focused exclusively on smallholder farmers and solar water pumping irrigation technologies to address their needs. In doing so, this analysis took into consideration the emerging experience with small-scale productive use pumping in East Africa. Small pumps of 80 Wp-150 Wp (e.g. Futurepump and SunCulture) make up the bulk of sales, while larger-sized pumps (e.g., Grundfos) are also frequently marketed to address differing water access and crop conditions.

Table 34 presents the estimated annualized off-grid solar cash market potential for smallholder value-added solar irrigation applications in Ghana, which has an estimated cash value of USD 171 million (see **Annex 2** for more details).

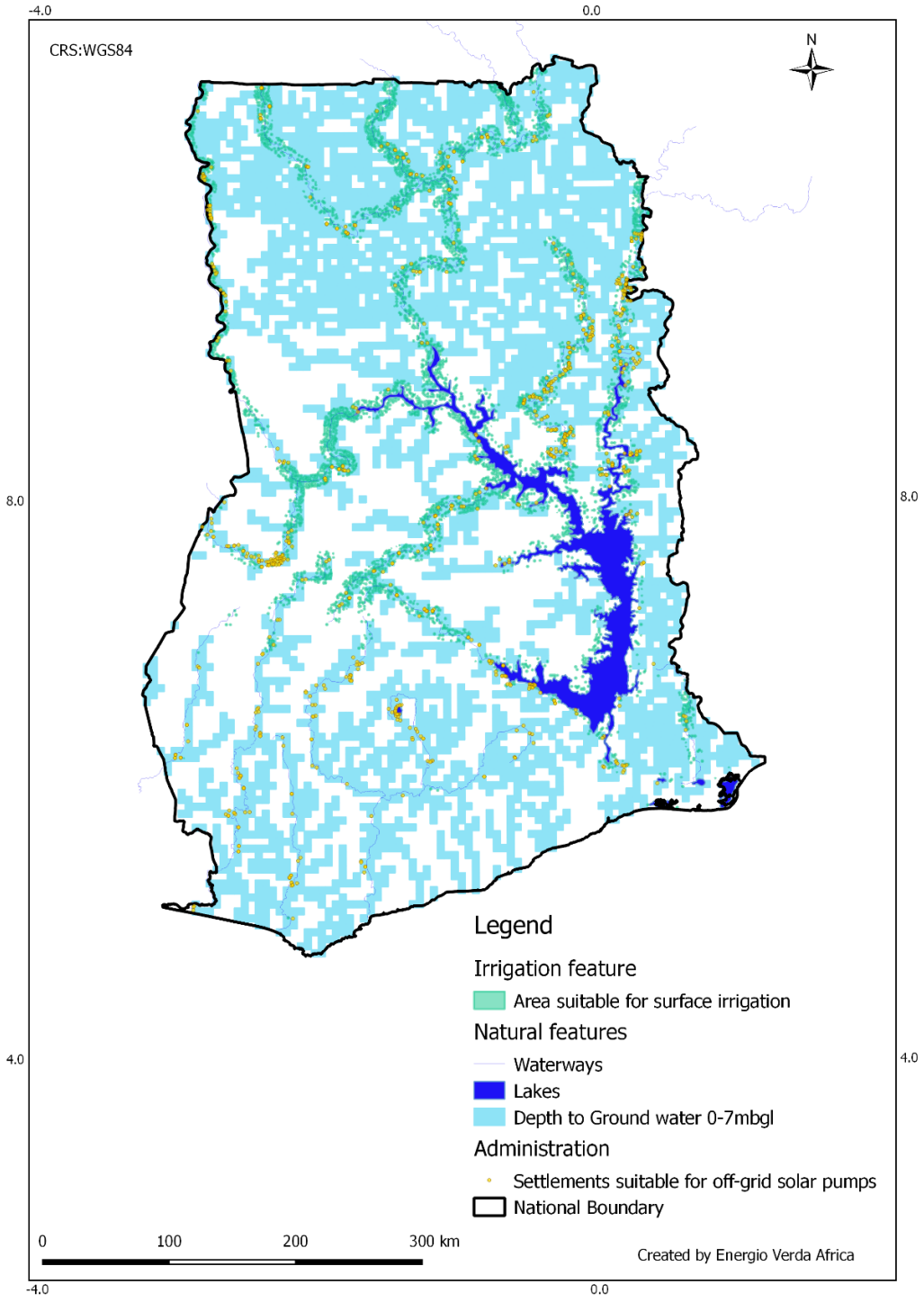
Table 34: Estimated Cash Market Potential for Value-Added Applications – Irrigation[157]

Estimated No. of Smallholder Farms Suitable for OGS Pumping for Irrigation	Units	kW Equivalent	Cash Value (USD)
1,583,333	263,889	31,667	$171,527,778

Source: Food and Agriculture Organization; World Bank; African Solar Designs Analysis

[155] *See* GIZ Powering Agriculture Toolbox on Solar Powered Irrigation Systems: https://energypedia.info/wiki/Toolbox_on_SPIS
[156] "LandLinks, Ghana Profile," USAID: https://www.land-links.org/country-profile/ghana/
[157] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 38: Area Suitable for Surface Irrigation and Identified Settlements Suitable for Off-Grid Solar Pumps



Source: British Geological Survey, Bureau of Statistics; ESA Climate Change Initiative and Ghana Statistical Service; Energio Verda Africa GIS analysis[158]

[158] NOTE: mbgl = meters below ground level
Sources: Mapping provided by British Geological Survey © NERC 2012. All rights reserved; Irrigation area identified from a Land Cover data set through the ESA Climate Change Initiative, Land Cover project 2017. © Modified Copernicus data (2015/2016): https://www.esa-landcover-cci.org/?q=node/187

Solar Powered Milling:

Cereal crops like maize, sorghum, millet, and rice provide an opportunity for value addition through hulling or milling. Off-grid communities use maize or rice milling equipment that is typically powered by diesel generators. Discussions with off-grid community groups revealed that although many are aware of the long-term cost savings associated with solar powered mills, the up-front cost of purchasing equipment was viewed as too high.

Table 35 presents the estimated annualized off-grid solar market potential for smallholder value-added solar grain milling applications in Ghana, which has an estimated cash value of USD 17 million (see **Annex 2** for more details).

Table 35: Estimated Cash Market Potential for Value-Added Applications – Milling[159]

Estimated No. of Solar Mills	Units	kW Equivalent	Cash Value (USD)
21,132	1,057	6,868	$17,170,058

Source: Food and Agriculture Organization; African Solar Designs analysis

Solar Powered Refrigeration:

Solar-powered refrigerators and freezers in rural areas serve multiple purposes, including to store milk, fish, meat and vegetables to extend the life of produce and reduce losses. In addition to storing produce, ice-makers can increase the income of rural SMEs by providing ice to businesses that require cold storage (stores, restaurants etc.).

Table 36 presents the estimated annualized off-grid solar market potential for smallholder value-added solar refrigeration applications in Ghana, which has an estimated cash value of USD 1.5 million (see **Annex 2** for more details).

Table 36: Esimated Cash Market Potential for Value-Added Applications – Refrigeration[160]

Off-grid Market Centers	Units	kW Equivalent	Cash Value (USD)
2,188	109	602	$1,504,250

Source: Solar-Powered Cold Hubs, Nigeria; African Solar Designs analysis

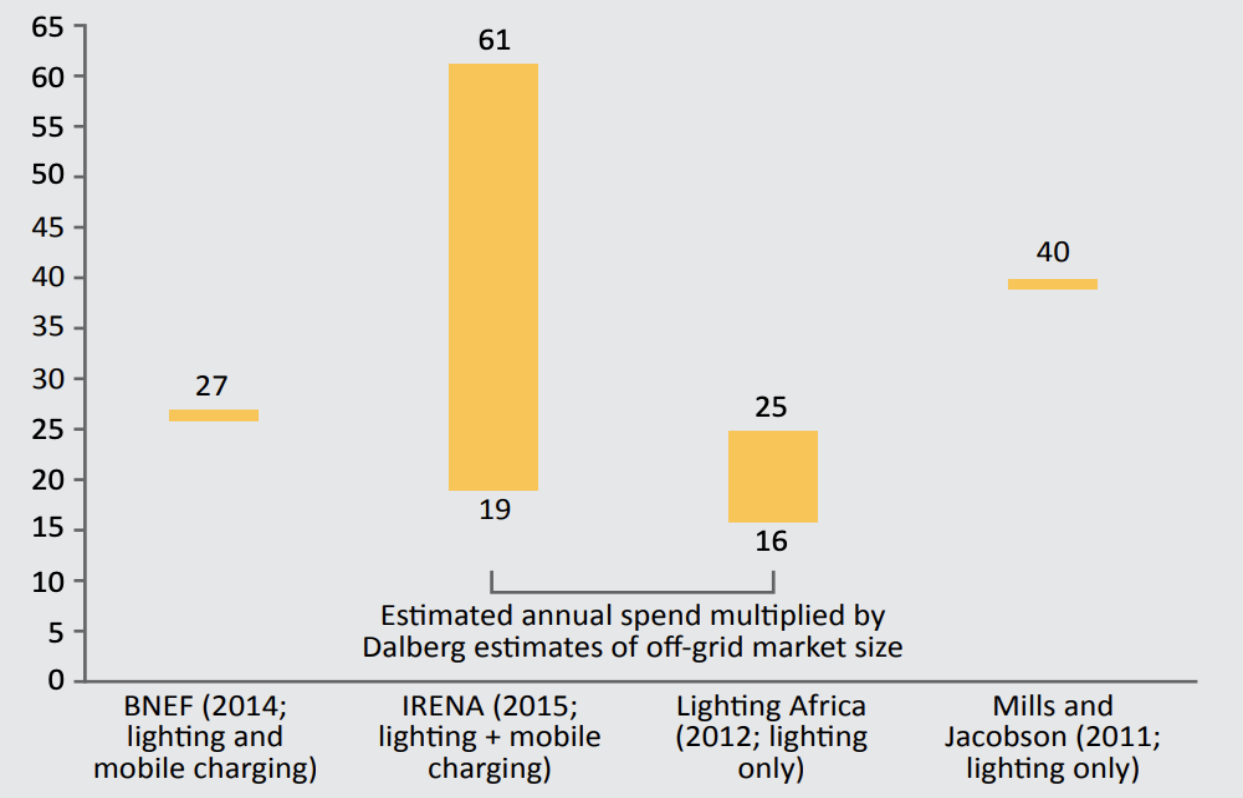
Ultimately, the ability for an agricultural community to benefit from productive use applications has as much to do with access to markets and improved crop inputs, as it has to do with the pricing and availability of financing to purchase the equipment. Hence, the macroeconomic approach used to carry out this market sizing does not account for country-specific cost and supply chain constraints.

- **Connectivity Applications**

Mobile phone charging stations/kiosks make up a critical segment of off-grid solar demand, as the market for solar phone charging is expected to grow significantly in the near-term. Household rates of mobile phone ownership often greatly exceed rates of electricity access, while households spend a significant share of income on lighting and phone charging (**Figure 39**). Increasingly, off-grid solar devices, such as lighting devices, also include phone-charging capabilities that enable owners to engage in mobile-phone charging businesses.

[159] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[160] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.

Figure 39: Estimated Annual Off-Grid Household Expenditure on Lighting and Mobile Phone Charging[161]



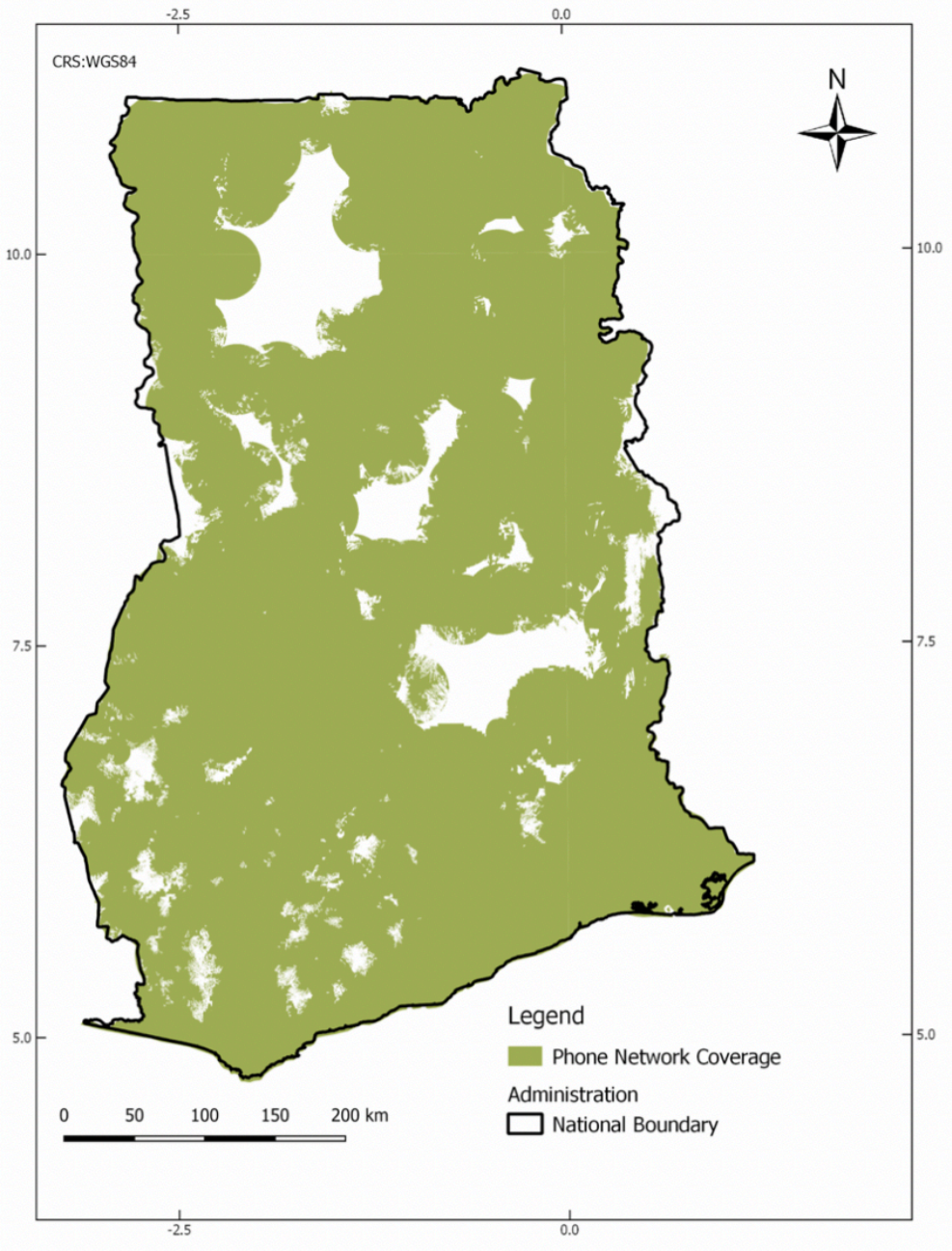
NOTE: Figures in Billion USD

Source: Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP

Figure 40 shows the relatively broad geographic coverage of cellular signals across the region. Cellular connectivity is essential for solar PV markets. In many African countries, mobile phone charging provides a primary productive use application for off-grid solar. Mobile phone access – and more importantly connectivity – helps drive commerce and employment in rural areas. The penetration of mobile money services is also critical, as it drives greater financial inclusion, expands consumer financing options and further increases demand for phone charging enterprises. Above all, mobile phones and connectivity are a necessary precursor to PAYG solutions in the OGS sector. Countries with expanding mobile phone coverage and especially broadband internet users are more attractive to PAYG solar companies (**Figure 16).**

[161] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

Figure 40: Mobile Phone Network Geographic Coverage[162]



Source: GSMA

The analysis of the potential solar-powered phone charging market was based on the country's mobile phone penetration rate, rural population rate, and the average costs of OGS phone charging appliances. **Table 37** presents the estimated annualized cash market potential for off-grid solar mobile phone charging enterprises in Ghana, which has an estimated cash value of USD 14.9 million (see **Annex 2** for more details).

[162] See **Annex 2** for more details

Table 37: Estimated Cash Market Potential for Mobile Phone Charging Enterprises[163]

Mobile Subscribers[164]	Rural Population (%)[165]	Units	kW Equivalent	Cash Value (USD)
18,900,000	45%	17,381	6,952	$ 14,982,022

Source: GSMA; World Bank; African Solar Designs analysis

2.3.3 Ability to Pay and Access to Finance

The above analysis illustrates that there is a sizeable off-grid solar cash market for productive use applications in Ghana. However, more research needs to be done in each segment to better understand affordability of OGS appliances and equipment based on ability and willingness to pay as well as other factors such as access to finance and ultimately whether the expenditure for the equipment is justifiable given increased revenue/productivity in the long-term.

The value-added market for water pumping for irrigation indicates that increased revenues from the use of solar appliances would justify the expenditure for the equipment – although as mentioned, agricultural productivity also depends on other environmental and market factors that are specific to each country. Solar powered irrigation systems may require a financed solution to be profitable investments for farmers, as their cost may exceed benefits depending on how the systems are designed and what components are used.

With regard to microenterprises, further study is needed to determine the impact of OGS on this sector, especially as it relates to income and affordability of the sectors analyzed (barbers and tailors). Providing solar-kits through subsidized micro-credit schemes can lead to productive uses and boost household income. The focus group discussion yielded additional insights into the off-grid solar PUE sector from a consumer point of view:

- Many companies cannot afford the up-front cost of solar products and systems. A potential solution to this problem would be to implement a third-party ownership system and increased access to financing. IFC has recently instituted a facility whereby it will cover up to 50% of the risk of loans to SMEs that are investing in climate smart equipment including solar appliances.[166]
- The Energy Sector Strategy Development Plan provides that the GoG will finance and implement PUE pilot projects as it strives to achieve universal access to electricity by 2020. On the other hand, the fact that productive use appliances are associated with government programs sets a low-price expectation amongst end-users who are accustomed to receiving such appliances for free.
- The financing tool for solar appliances should not only be provided to end users, but also local and regional suppliers to enable them to effectively market to available end users.
- Despite public and donor-led interventions to lower financial constraints, firms in rural areas still struggle to access financing solutions. This is especially the case for farmers that have invested in milling or solar drying but have not implemented irrigation schemes that would allow them to harvest crops year-round.
- There is also a high degree of skepticism regarding the reliability and quality of solar powered appliances, and as such, more should be done to raise awareness and set appropriate standards for solar products.

[163] Estimated units, kW equivalent and cash value are annualized to reflect typical lifespan of OGS systems; see **Annex 2** for more details.
[164] "The Mobile Economy: Sub-Saharan Africa," GSMA, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download
[165] World Bank: Rural Population (% of total population) https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS
[166] Press Release: "IFC Invests in Bank of Africa to Expand SME Lending in Eight Countries," June 4, 2018 https://ifcextapps.ifc.org/ifcext/pressroom/ifcpressroom.nsf/0/947B76E4C106A246852582A200440E1C?OpenDocument

2.4 Supply Chain

This section reviews the off-grid solar supply chain in Ghana, including an overview of key actors, solar products and services, business models, and sales volumes. The section also analyzes the role of informal market players and the impact of uncertified products. The section concludes with an assessment of local capacity and the needs of the supplier market segment. The data presented in this section was obtained through desk research, interviews with local officials and industry stakeholders, focus group discussions and surveys of international and local solar companies (see **Annex 2** for more details). The tier system used to classify solar companies throughout this section is described in **Table 38**.

Table 38: Solar Company Tier Classification

	Classification	Description
Tier 1	Startup companies	• Less than 3 full time employees • Less than 300 SHS or Less than 1,500 lanterns sold • Less than USD 100,000 annual revenues • Does not have access to outside finance except personal loans and may have a business account
Tier 2	Early stage companies	• 3 to 25 full time employees • 300 to 30,000 solar home systems or 1,500 to 50,000 lanterns sold
Tier 3	Growth/Mature	• More than 25 full time employees • More than 30,000 solar home systems or 50,000 lanterns sold • More than USD 3 million annual revenues • Has a credit line at a bank and financial statements • Raising equity or other outside financing

Source: ECOWAS Center for Renewable Energy and Energy Efficiency

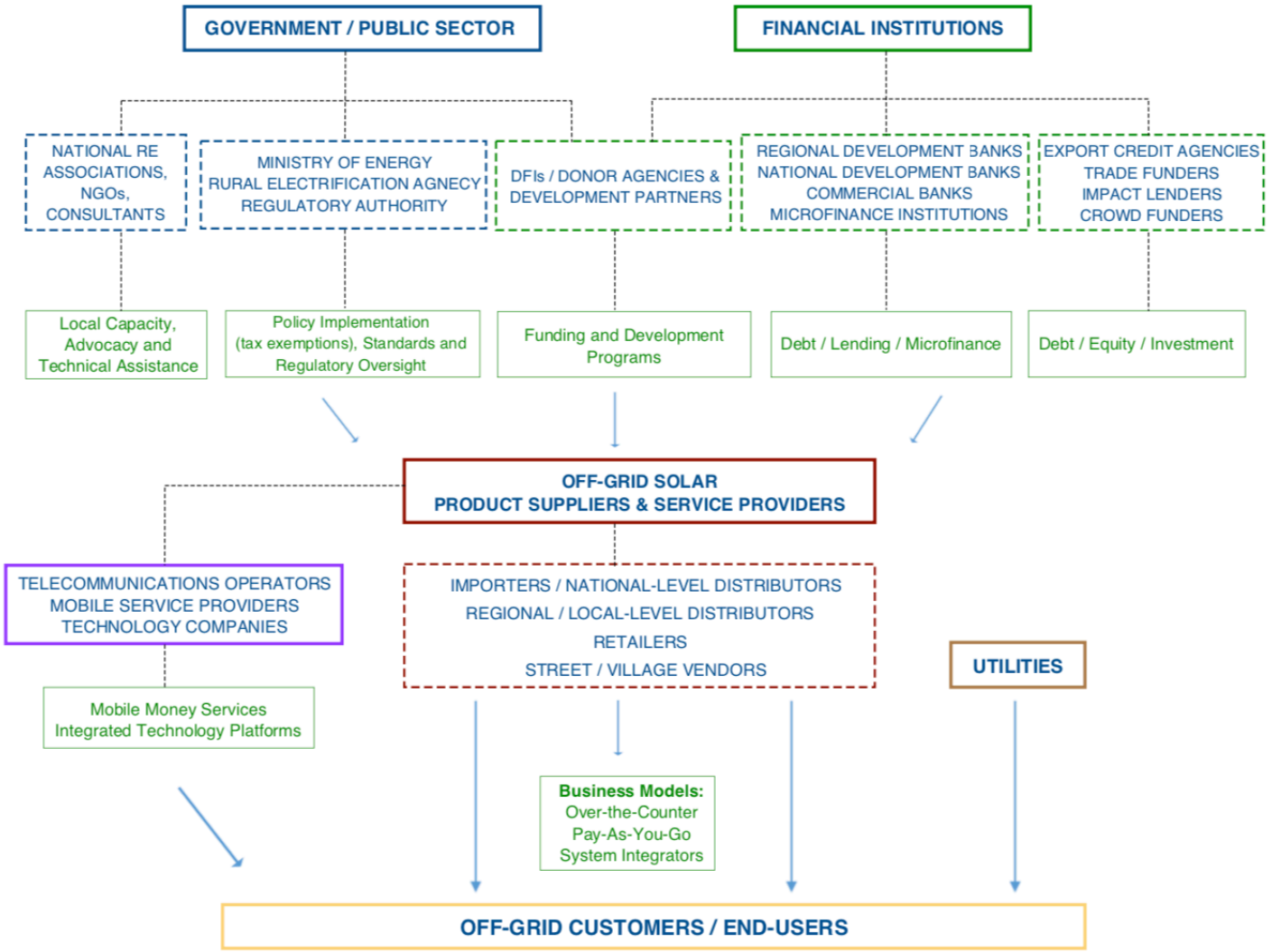
2.4.1 Overview of Commercial Market for Solar PV Equipment

The off-grid solar supply chain in Ghana is made up of a wide range of stakeholders – importers, distributors, wholesalers, retailers, NGOs, and end-users (**Figure 41**). The market is experiencing a period of growth. Existing distribution channels are typical of a mature market, with PAYG system development, a growing over-the-counter market, and many local and regional suppliers having established partnerships with international manufacturers. Most supply chain stakeholders are concentrated in Accra.

Ghana has one of the most dynamic off-grid solar markets in the region. A variety of solar products and systems are offered by companies in the market (by both the formal and informal sector) and, as examined in further detail below, there are a number of business models currently being utilized. While rural and peri-urban consumers make up the largest share of the off-grid solar market, urban households, both electrified and non-electrified, are also a key consumer market, as they may have greater ability to afford OGS products and systems. Moreover, power connections in urban areas of Ghana are often not reliable (**Figure 4**), leading to expanded use of off-grid solutions.

New actors have recently emerged in Ghana's off-grid market – early stage PAYG market players and system integrators, acting as agents of large solar companies and distributors. While large Tier 3 companies selling certified products play a central role in the market, the informal sector remains a key factor. Surveys of local industry players and focus group discussions noted that a clear regulatory framework was necessary to provide appropriate incentives for the private sector and to address the widespread sale of low-quality, uncertified products, which is hindering development of the OGS market in Ghana.

Figure 41: Off-Grid Solar Market and Supply Chain Overview



Source: GreenMax Capital Advisors

2.4.2 Overview of OGS Companies in Africa and Level of Interest in the Region

The African off-grid solar market has experienced rapid growth over the last five years. This growth can largely be attributed to the emergence of a progressively diverse, global pool of manufacturers and distributors, decreased system costs and an increase in three major product categories – pico solar, Plug-and-Play SHS, and component-based systems.[167] Leading solar companies such as Greenlight Planet, D.Light, Off-Grid Electric, M-KOPA Solar, Fenix International, and BBOXX represent the largest share of the African off-grid market and are joining other players in West Africa and the Sahel, including Lumos Global, PEG Africa, Barefoot Power, Yandalux, Schneider Electric, Azuri Technologies, Solarama, AD Solar, Enertec, SmarterGrid, GoSolar, Total, Oolu Solar, EnergenWao and SunTech Power to list a few.

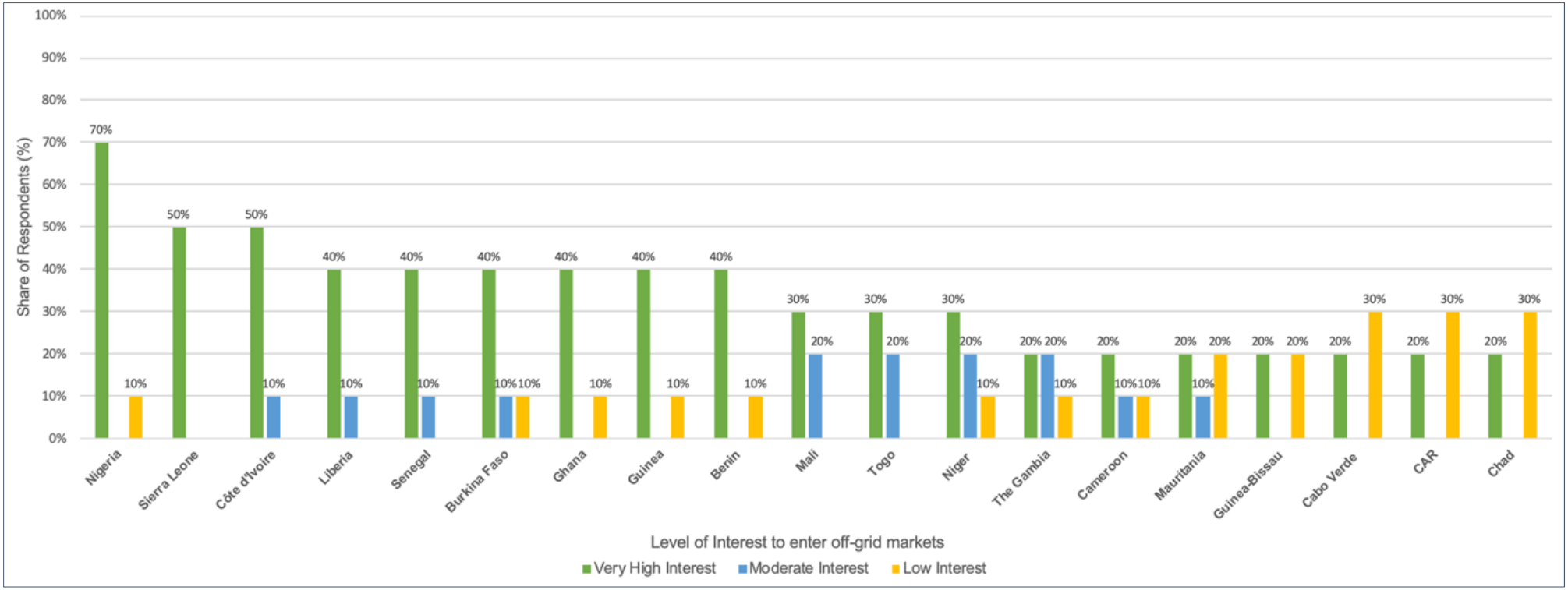
Market entry into Africa began in East Africa for a majority of the leading companies, a trend that can be attributed to advancements in mobile money transfer systems such as M-Pesa that have facilitated the PAYG off-grid business model. As the East African market becomes more crowded and mobile money services spread across the Continent, many international off-grid solar companies have recently entered markets in West Africa and the Sahel. The regional market grew from being nearly non-existent in 2013 to accounting for 9% of worldwide sales (20% of SSA) with over 2 million systems sold in 2017.[168]

Over 500 solar companies have been identified operating across the region, many of which are small local players. These local distributors either operate independently or act as local affiliates of larger international companies operating in this space. The majority of companies in the region are primarily Tier 1 and Tier 2 companies, with relatively few Tier 3 companies. The highest concentration of Tier 3 companies was identified in Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria and Senegal.[169]

A survey of large international solar companies that assessed *inter alia* their level of interest in entering the off-grid markets in West Africa and the Sahel is presented in **Figure 42**. The survey found that among respondents, companies expressed the most interest in Nigeria, Sierra Leone, and Côte d'Ivoire, with at least half of respondents indicating a "very high level of interest" in these markets. There was also a relatively high level of interest in Liberia, Senegal, Burkina Faso, Mali and Togo, with at least half of respondents indicating a "very high" or "moderate" level of interest in these markets.

[167] "Off-Grid Solar Market Trends Report, 2018," Dahlberg Advisors and Lighting Africa, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf
[168] Ibid.
[169] "Insights from Interviews with Off-Grid Energy Companies," ECREEE, (June 2018).

Figure 42: Level of Interest in Off-Grid Markets in West Africa and the Sahel among Major Suppliers[170]



Source: Stakeholder interviews; GreenMax Capital Advisors analysis

[170] NOTE: This is not a representative sample of respondents (sample size = 10 respondents). The figure is meant to provide feedback from "major suppliers" of off-grid solar products and services and gauge their level of interest in entering specific ROGEP country off-grid markets. Respondents are all GOGLA members and are either already active in the West Africa and Sahel region or seeking to enter it. The figures presented are the share of respondents (%) who indicated their level of interest in a given country.

2.4.3 Solar Market, Products and Companies in Ghana

This section characterizes the current formal market (local and international companies) including recent sales trends, the main solar products, brands and prices.

- **The Formal Market – Local and International Companies**

Focus groups and stakeholder interviews identified about 30 companies operating in Ghana's solar sector, offering a wide range of products and services to consumers throughout the country (see **Annex 2** for a complete list of identified companies). In addition to local firms, the formal market includes international players that enter the market to install systems for donor-funded projects. Formal market players are largely Lighting Global and GOGLA affiliated companies that are members of the Ghana Association of Solar Industries. Several of these firms have a regional presence in other West African markets and typically operate through partnerships with manufacturers and with local or international distributors.

Although highly advanced, Ghana's off-grid solar market is still growing quickly and has one of the highest concentrations of active off-grid solar companies in West Africa and the Sahel. A study undertaken by ECREEE in 2018 identified seven Tier 3 companies in the market, which ranked Ghana behind only Mali (16), Senegal (11), Côte d'Ivoire (10) and Nigeria (9) in the region.[171] The largest international Tier 3 companies operating in the country are Azuri Ghana, PEG Ghana and Off-Grid Electric (OGE). Three Tier 2 companies were also identified – Barefoot Power, Yingli Solar and Dutch & Co., along with many more Tier 1 firms.

Many companies operating in the market are manufacturer representatives, obtaining their products from global manufacturers and representing international brands. They deal in a wide range of products, from solar pico lanterns to plug and play systems to very large solar systems, and many companies offer PAYG financing services to their customers. While Azuri, PEG Ghana, and Barefoot Power focus more on households and communities, other companies such as Franerix Solutions specialize in multiple modular and very large solar systems. Most of the interviewed suppliers have social, institutional, and government entities as well as large private companies as clients. Many of the companies are self-financed but also have access to bank loans, grants and equity.

- **Sales Volumes and Revenue**

Focus group participants indicated that it is challenging to assess the size of the current market due to a lack of standardization in pricing from one company to another and a shortage of sound statistical data. Moreover, during surveys and FGDs, companies were reluctant to share confidential data on sales volumes and market shares. Local industry stakeholders described the market as having significant volume of sales distributed between hundreds of larger installations (>1 kW) and tens of thousands of consumer product sales along with institutional system market activity.

Using reports published by GOGLA, some basic market information is presented in **Table 39** and **Table 40**. It is important to note that this data only includes figures from GOGLA-affiliated companies and certified product sales and is therefore not fully representative of off-grid solar market activity in Ghana.

[171] "Insights from Interviews with Off-Grid Energy Companies," ECREEE, (June 2018).

Table 39: Total Sales Volume and Cash Revenue for Stand-alone Systems in Ghana, 2016-2017[172]

Sales Volume / Revenue	2016	2017	Total
Total Volume of Products Sold (Units)			
Total Volume of Products Sold	51,006	63,652	**114,658**
Pico Solar	47,946	54,104	**102,050**
SHS	3,060	9,548	**12,608**
Total Cash Sales Revenue (USD)			
Total Cash Sales Revenue	$2,293,028	$711,074	**$3,004,102**
Pico Solar	$1,972,004	$682,631	**$2,654,635**
SHS	$321,024	$28,443	**$349,467**

Pico solar products categorized as 0-10W
SHS products categorized as >10W

In 2016-2017, about 90% of the overall share of OGS products sold and 92% of total sales revenue in West Africa were pico solar products compared to 10% of products sold and 8% of sales revenue were SHS.

Table 40: Cash and PAYG Sales Volume and Revenue for Pico Solar Products, H1 2018[173]

Sales Volume / Revenue	Cash	Share (%)	PAYG	Share (%)	Total
Total Sales Volume Ghana	**13,472**	**51%**	**12,688**	**49%**	**26,160**
Total Sales Volume West Africa	194,521	65%	104,520	35%	299,041
% of Total Sales Volume in West Africa	6.9%	-	12.1%	-	8.7%
Total Sales Revenue Ghana	**$915,725**	**25%**	**$2,753,189**	**75%**	**$3,668,914**
Total Sales Revenue West Africa	$14,972,591	50%	$15,008,999	50%	$29,981,590
% of Total Sales Revenue in West Africa	6.1%	-	18.3%	-	12.2%

NOTE: H1 = First half of year

Source (Tables 39-40): GOGLA, Lighting Global and World Bank; GreenMax Capital Advisors analysis

- **In 2016-2017, 114,658 units were sold in Ghana for a total amount of over USD 3 million.** Sales volumes have increased by 25% between 2016 and 2017, from 51,006 to 63,652 units, while cash sales revenue has decreased by 69% over the same period, from almost USD 2.3 million to USD 711,074 over the same period.

- **In 2017, Ghana's sales accounted for 10% of volume and 12% of cash sales revenue in West Africa**. Ghana is one the most developed solar market in the region. In 2017, 63,652 solar products were sold, with 40% increase between H1 2017 and H2 2017. Cash sales amounted to USD 711,074 in 2017, representing 12% of total cash sales revenue in the region. In H1 2018, Ghana has registered a decrease compared to H2 2017, with sales comparable to the level of H1 2017 (at about 26,000 units)

[172] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf; and
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf
[173] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2018): https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2018-opt.pdf

- **Pico PV products represent the vast majority of products sold**. Based on regional sales data on product categories, 89% of products sold in 2016-2017 were pico lanterns (about 102,050 units), accounting for 88% (USD 2,654,635) of total cash sales revenue.

- **PAYG is widely used by Ghanaian solar companies, and total PAYG sales revenue accounted for USD 2.8 million in H1 2018**.[174] The H1 2018 GOGLA report, which provides data on PAYG transactions, found that PAYG sales volume accounts for almost half of total sales in Ghana in H1 2018. It also indicated that PAYG's sales revenue (USD 2.8 million) is significantly higher than cash sales revenue (USD 915,725) for the same period. PAYG sales revenue in Ghana represented 18% of total PAYG sales in West Africa and was second only to Côte d'Ivoire in the region.

➢ Main Solar Products and Components

Common solar product brands are presented in **Table 41**. The list does not include non-certified / counterfeit brands that are also common in the grey market.[175]

Table 41: Common Off-Grid Solar Products and Components in Ghana

Systems	**Companies**
Distributors of Pico Solar Lanterns	PEG Africa, YingLi, North Lite Solar, Burro
Single Module distributors	Solar light, Süka, Franerix, Nocheski, Sunpower, Power and Co, Deng, YingLi, NorthLite Solar
Multi module system distributors	Solar light, Süka, Franerix Solutions, Nocheski, Sunpower, Power and Co, Deng, YingLi
Very large system supplier	Solar Light, Süka, Franerix, Sunpower, Wilkins Engineering, Deng
Products/Components	**Brands**
Pico/plug & play system	Sun King Pro, ORB Energy, Sunvis Solar, Powetas (Austria), Barefoot, Powertap, SOLelectric plug and play
Single modular system	Burro (Koforidua), VVSDE, Energyrum
Solar module	Jinko (China), Amerisolar (USA), Helios (China)
Inverter	MPP Solar (Taiwan), Opti Solar (Taiwan), Kaco (Germany), Frokus (Netherlands), Victron (Netherlands)
Lead Acid Battery	Victron (Netherlands), Ritar Power (China), Narada (China)

Source: Stakeholder interviews

➢ Market Prices

Table 42 presents average prices for off-grid systems and components in Ghana's solar market.

Table 42: Estimated Prices of Solar Systems and Components in Ghana

Off-Grid System / Component	**Price range (USD / per unit)**
Pico solar and Plug and Play	$25-$40
SHS (average, rooftop PV for rural households)	$1,500
Solar Module (0.265 kW- 0.26 kW)	$71-$230
Inverter (0.6 kW-50 kW)	$154-$6,000
Lead Acid Battery (100 Ah-220Ah)	$144-$500

Source: Stakeholder interviews

[174] In the GOGLA H1 2018 Report, the methodology has slightly changed compared to 2017 – in addition of cash sales, affiliated companies also reported PAYG sales

[175] In this context, "grey market" refers to products that are not Lighting Global certified that are typically sold over-the-counter at very low prices. Some grey market products are counterfeit or replicas of certified products that undercut the markets of certified products

- **Importation Clearance Processes**

For the importation of solar products, several government agencies are involved in the importation process of solar products in Ghana: The Energy Commission, Ghana Revenue Authority, Ghana Ports and Harbours Authority and Ghana Standards Authority. There is a total exemption of custom taxes on solar home systems (and its components) and also on solar pico PV products. The importation process is relatively fast in Ghana, as it takes about 40-45 working days to import products. It takes about 30 days on average for the cargo to reach Ghana (depending on the shipment's country of origin and on the freighter), about five days for custom clearance and an additional five days to get the approval of local authorities. The Ghanaian Government has developed and implemented specific provisions based on GOGLA and Lighting Africa standards in order to ensure the quality of products entering the market.

2.4.4 Overview of Business Models

- **Company Approach to Market**

Ghana's market is at a growth/mature stage. Market players are well established, including many power engineering companies, and have worked for more than 10 years in the industry. Formal solar companies offer a wide range of products, from solar lanterns and plug and play solar systems, to single and multiple modular systems and very large systems (defined as systems above 1KW that required specialized design and installation including after sales services).

Many companies are direct importers and distributors who have established strong partnerships with foreign manufacturers, representing their brands. In exchange, manufacturers avail credit terms to Ghanaian suppliers and have helped with regards to technology transfer and capacity building. The oldest formal company surveyed has been in business since 1988. Households (including large-income clients in urban areas) seem to be the most important clients, even though companies deal with government agencies and NGOs as well. PAYG is widely used to reach the base of the pyramid segment of the market in rural areas. Over-the-counter and cash sales is still the dominant model, not only for the non-standard/informal market but also for wealthy customers who can afford to make one-time cash payments in urban areas.

- **Business Models**

There are four primary business models used in the market (**Table 43**), although in reality solar companies utilize a number of business models to reach a variety of clients:

- **Over-the-counter cash sales** include both informal and formal components. Many traders simply offer solar products over-the-counter. Formal sector solar companies also stock modules, batteries and balance of system and offer them over-the-counter to do-it-yourselfers and agents. In Ghana, cash sales are also for better off customers, who are able to make a one-time cash payment to buy solar systems.
- **System integrators** handle large systems and projects. They design, procure and install systems which range from high-end residential sites, to institutional power to mini-grids. Local integrators represent international solar, inverter and battery brands with whom they partner with on projects.
- **Plug and play and pico suppliers** cooperate with many of the major OGS brands to distribute products in the country. Sellers of plug and play systems target customers who can afford more than simple pico lanterns (products are usually sold through PAYG).
- **The PAYG sector** is still in its early stages but is growing rapidly representing 49% of sales volumes and 75% of revenue in H1 2018. Suppliers are building up client bases which number in the tens of thousands and are quickly evolving to develop credit mechanisms that fit with local income patterns. The margins are made from subscriptions of thousands of consumers who buy systems through created

accounts. The task of installation and after sales services is undertaken by agents. Common products sold include plug and play systems that are fully designed. In Ghana, surveyed stakeholders indicated that rural customers are major customers of PAYG system, as they need payment facilities.

Table 43: Overview of Off-Grid Solar Business Models

Business Model	Strategy and Customer Base	State of Development
Over-the-counter solar market	**Formal:** Retailers in Ghana are both large-scale (acting as suppliers and distributors) and medium size and are mainly located in large cities and towns around the country. They sell lighting/electrical products, including solar, pico systems and also large panels for urban customers. **Informal:** Kiosks, street vendors form a key pico-product retailer segment (that has not been fully explored). They sell low-priced products which are often short-lived. They have been seen as the entry points for black market low quality solar products to the country.	Mature commercial market Early stage commercial development
System integrator	Integrators operate out of central offices with small specialized staff. They do not typically carry stock for sale over-the-counter. Instead, they deal directly with consumers and institutional clients and provide as per orders. Integrators target the NGO/donor market and participate in procurement tenders for supply and installation of larger systems.	Mature commercial market
Plug and Play system supplier	These suppliers distribute equipment to retailers' projects, rural agents, community groups and over-the-counter. Traders of plug and play often sell these devices as part of other businesses.	Early stage commercial development
PAYG Sales	PAYG companies seek to implement the rent-to-own payment-based models used successfully in other countries. The business model is data-driven and relies on mobile money services and a network of agents to meet last-mile customers. Innovative OGS PAYG collaborations between shop-owners, mobile-operators and other larger local businesses are being tested. In Ghana, the initial deposit represents between 10 to 20% of the total cost of the product) and the remaining amount is paid in installments. If the customer cannot repay anymore, the system is taken away and given to another customer, who will continue to repay the remaining amount (the new customer takes over from the default customer).	Early stage commercial development

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

- **Company Financing**

With so many companies utilizing the PAYG model to sell off-grid products and systems on credit (sometimes with lengthy repayment periods), it can become difficult for companies to finance their operations, grow their business and cover transport and inventory costs. In addition to financing customer payment options, suppliers also require significant working capital to purchase equipment, conduct marketing campaigns, and cover field costs. Distributors of international OGS products receive basic trade finance and marketing support options, though typically limited.

Most of the firms surveyed in Ghana are self-financed, and many combine it with other sources of financing, including bank loans (although many smaller firms find bank loans inaccessible / too expensive). Some of the largest companies (e.g. PEG Ghana) have access to equity, while a few players are also supported by donor funding/grants. FGD stakeholders underlined that Government rural electrification/solar program (GEDAP) has contributed to financial success of many solar companies and service providers.

While large international companies operating in the country have access to loans, equity and other international funds to finance their growth and development, many local companies in Ghana are unable to raise funds to expand their business. Local financiers have yet to develop an appetite for the solar sector. Local banks are extremely conservative with regard to solar enterprises. Commercial financiers – including

banks and MFIs – are not set up to service solar distributor financing requirements. Local SME financing is not available to support businesses in their growth phase. If it was available, companies would make use of credit line financing against the signed contracts with major commercial clients, large NGOs or donors.

When importing, companies are exposed to considerable FOREX risks because they must cover costs of equipment in foreign currency. When projects are delayed, during seasonal low-income periods or when products are delayed in port, dealers must bear FOREX losses. The lack of consumer financing arrangements impedes the growth of the solar market because distributors must take all finance risks and cannot plan with commercial or MFI financing to grow their business.

- **Evolving Business Models**

Ghana presents a fertile ground for new business model innovations. New models will require partnerships between developers, solar distributors, telecommunications companies, commercial finance and the retail sector. One of the results of the FGD discussions was a list of potential partnerships that can be explored to enhance existing and new business models (**Table 44)**.

Table 44: Evolving Off-Grid Solar Business Models

Partnership	Description
Solar Distributors	• Improve efficiency within the supply/distribution chain, positioning them to be able to manage distribution, seek potential for long-term credit lines and capital infusions • Develop better contract terms between large local suppliers in Ghana with foreign manufacturers • Test new sales and distribution strategies that increase sales at minimum cost • Prove solar market potential, ultimately attracting a strong group of competing players that scale up solar product access
Commercial financiers	• Commercial financiers are key to unlocking working capital and consumer finance and enabling the market by providing both the funds and means of transferring these funds • Develop financial products for both distributors (financing for working capital needs) and off-grid solar consumers (consumer financing for purchase of systems)
Telecommunications companies and technology providers	• Bring together telecommunications operators, mobile service providers and technology companies and solar supplier/distributor companies to develop Pay-As-You-Go technology platforms • Encourage telecommunications partners to distribute off-grid solar systems through their existing network of agents
Business/Retail Sector	• Comprises networks of retail stores that cover the entire country and provide all types of domestic and agriculture goods for the rural community • Encourage linkages between specialized solar companies and these networks so as to facilitate the increase of the distribution network at a lowest cost possible • Provide promotional tools for local retailers to promote solar products to households/SMEs • Facilitate microfinancing for the domestic market through these networks
Advocacy Bodies	• Capitalize on GoG and donor efforts to (i) facilitate interagency dialogue and oversee policy proposals on new business models and (ii) enhance legislative changes to support the sector

Source: African Solar Designs analysis

2.4.5 The Role of Non-Standard Players in the Market

Stakeholder interviews and FGDs were unable to estimate the over-the-counter informal market in terms of volumes and cash sales. The latest GOGLA sales report[176] nevertheless gives estimates of the share of GOGLA affiliated companies (those sharing data) market share in Ghana. GOGLA-affiliated companies would represent about 30% of the whole solar pico market (<11Wp) and about 70% of the total plug and play and SHS market (>11Wp). Non-affiliated companies, including non-standard companies, would thus account for 70% of the total solar pico market, but only 30% of the overall SHS market.

Informal traders sell modules, inverters, batteries and pico-products. Given that informal sellers are largely unregulated and do not report sales figures, very little data is available on this sector. The sector, however, is very influential as it also dominates the market of lighting products imported mainly from East Asia. Informal traders understand growing consumer interest in solar solutions and sell competitively-priced low-quality products. Informal traders do not cooperate with the GoG or work on formal projects.

Informal traders play an important role in the market because they respond to consumer demand rapidly. Many traders do provide IEC-approved components – this means knowledgeable consumers and technicians can assemble quality systems from over-the-counter selections of components that informal traders sell. It is notable that some informal traders are gaining skills and improving product offerings. The presence of a large informal market, however, leads to issues with equipment quality that hamper development of the country's OGS market.

2.4.6 Equipment Quality and the Impact of Uncertified Equipment

Ghana's solar market is largely dominated by informal market players, selling equipment through electronics shops, hardware stores, kiosks and even street vendors. The over-the-counter sales strategies of this group is to provide low-cost, fast moving products. As a sector, informal retailers provide widely-used lighting products mainly from East Asia to rural customers. However, most of their product range does not meet Lighting Global standards. Moreover, given that the most of their lighting products are low-cost and short-lived, they also ignore and avoid regulations and their products lack warrantees.

All of the companies surveyed considered the presence of counterfeit, low-quality products in the market as a significant barrier to market growth. These products negatively impact the entire market by creating a misperception about product quality, which in turn undermines consumer confidence in solar equipment. Moreover, grey-market traders significantly undercut the prices of registered businesses who are still subject to taxes and import duties. Low prices of over-the-counter products make compliant products uncompetitive as many customers opt to buy non-compliant goods that are cheaper. However, more established players indicated that their long-standing years of experience have built trusting relationships with customers.

Surveyed companies recommended implementing effective monitoring and control procedures to better check the quality of products entering the country. Despite having GOGLA and Lighting Africa provisions in place to ensure the quality of products in the country, participants indicated that this was not doing enough to control the influx of low-quality products. Companies also highlighted the need for local quality standards, adapted to the country's specific conditions that industry players would agree upon. Feedback from focus group meetings suggested that there is an important role for the regulator, the Ghana Energy Commission and/or the Ghana Revenue Authority (GRA) to assist in enforcement of standards through mediation efforts between regulatory bodies, market players and consumers.

[176] GOGLA Global, Lighting Global and World Bank, June 2018.

2.4.7 Local Capacity to Manage Business Development, Installation and Maintenance

Ghana's solar market is poised to continue to grow if requisite technical assistance (TA) is provided. To operate effectively in the existing market, companies need a significant amount of both local and international technical and financial expertise, and an ability to make practical decisions about their operations. Companies face a number of technical competency requirements – the selection of approaches and solar PV technologies, the design of their associated marketing instruments and the implementation of related initiatives.

The synergy with formal training institutions has yet to be fully explored and most of the players in the industry are not adequately equipped with the skills needed to design and assess policies, understand and deploy technologies, grasp electricity user needs and ability to pay, and operate and maintain systems. Some of the other areas where TA and capacity building is needed to support growth of the solar market include (but are not limited to) the following:

- Provision of TA and training to public and private partners on the development of OGS power projects.
- Support in development of vocational training curricula for solar technicians by working with education institutions to adopt the curricula and implement training programs. This support could include development of community training materials to raise community awareness about the importance of solar PV technologies, the various uses ranging from household use, productive uses and institutional uses of energy, and related safety aspects.
- In order to ensure that interaction with local communities is seamless, the collaborating partners could develop a management training manual for villages addressing the different aspects of solar technologies as well. This could include supporting technicians with troubleshooting posters for on-site display that could help identify and tackle operational issues as they arise.
- Solar technicians were noted to be sparse for some areas and lacking in other areas; as a result, solar businesses send out teams from major cities/towns for any installation and maintenance work. Training people based locally in remote areas to support O&M of solar systems (e.g. battery replacement) could help address this issue and expedite market uptake.

2.4.8 Capacity Building Needs of the Supplier Market Segment

An analysis of the supplier market segment revealed a number of interrelated challenges, including financial, capacity, awareness and regulatory challenges. The focus groups and supplier surveys found that:

- The lack of capital was cited as the first major barrier to market growth by industry experts, even though Ghana seems globally to have access to a wider range of business finance than other West African countries: bank loan, equity, grants and government funding. Nonetheless, access to finance would help solar businesses, by facilitating the importation and distribution of goods, but also supporting logistics.
- While access to finance is less of a hurdle than most other West African countries, some established players still do not have access to bank loans, considered too expensive for their business.
- Reasons for denied finance by financial institutions included lack of collateral, lack of expertise in finance, the high cost involved in small transactions, and risk aversion.
- The gap between the capital and off-grid rural areas (wealthy urban customers and rural customers). In order to reach the wider market (off-grid rural communities), training of technicians should not be limited solely to Accra's market but adapted to the needs of targeted rural populations.
- FGD participants highlighted the gaps between urban/capital city consumers and rural consumers, with regards to customer needs and products sold, consumer finance and ability to pay. Participants indicated that one of the major barriers was an "identity crisis" within the solar sector, precisely because the market is dominated by suppliers from the capital which do not necessarily match the needs of rural

off-grid communities. Solutions should be found to answer all customer needs and target a wider market including Bottom of the pyramid customers.

- Knowledge, technical capacity and expertise is possessed by a few professionals in the industry working for large established solar companies; the majority of vendors lack the expertise or knowledge necessary to adequately service the market.
- Lack of quality control due to Government "open market policy" to disseminate solar lanterns across the country, resulting in a massive influx of inferior quality products. Although interviewed industry players understand the need to support solar with a policy that place customers first, they believed it should be accompanied by some sort of effective quality control on products entering the country[177].
- Improve regulations and develop framework to ensure product quality and address issues of low-quality products that compete with certified products sold by formal companies

Table 45 presents various areas of support and associated capacity building for the OGS supply chain in Ghana. Attention should be given to the following:

- **Importers/Suppliers**: Ensure effectiveness of VAT and tax exemption, while reducing the cost of stock, transportation and other logistics on PV products. Despite a full tax exemption introduced on solar product, companies still mention high taxes as a major barrier, which could suggest its implementation is not as effective as is could be. Grow further credit financing of solar PV products (already availed to many solar companies in Ghana), which enables gradual payment of solar product hence reduced shock on high upfront cost that lead to low adoption of the technology.
- **Over-the-counter/ System Integrators/PAYG**: Focus on growing the number of solar technicians who are adequately skilled to support the supplier network, especially in rural areas. Formalizing this through regulation to require only licensed technicians to design and install solar PV systems is critical. This should be complemented by equally robust efforts to build the capacity of all stakeholders.
- **Consumers**: Deal with sociotechnical barriers: Although PV technology has advanced tremendously in the last decades, there are still several sociotechnical barriers to adoption, including the local conditions of the user's environment and the political and financial arrangements of the market. Like most countries in the region, various counterfeit solar PV products have infiltrated the market. Implementation of the existing regulations on quality/standards could boost market growth.

[177] See also Task 1, "Gaps in the off-grid policy and the regulatory framework" Table.

Table 45: Capacity Building and Technical Assistance for the OGS Supply Chain in Ghana[178]

Area of Support	Description	Rationale
Cost of stock and transportation Taxes	• High costs of stock, logistics and transportation are mentioned as major issues by companies. • While FGDs participants acknowledged free duties on solar components, interviewed solar companies still mentioned high taxes as a major concern to them.	• Costs of solar products are inflated by high transport and logistics costs • Costs are passed on to customers, making solar less affordable
Quality control/certification center	• Suppliers are able to effectively monitor the quality of products imported in Ghana • Ensure that imported products are suitable/relevant to the Ghanaian local context (local standards)	• Ensure the quality of products and face the influx of low-quality products • Maintain the trust established between solar industry and customers
Consumer education programs	• Supplier and consumer education and benefit awareness campaigns, targeting both segments, distributors and retailers, with a focus on rural populations	• Overcome negative perceptions and strengthen trust established over the years • Influence purchase decisions, with a focus on rural areas (customers in Accra are familiar and different) and ease access to distribution channels
Inventory financing facility	• Concessionary credit line so financial institutions can access liquidity for solar market lending; create frameworks that avail loans to solar companies (small household systems, larger PV installations, and mini-grids), pilot with aim of scaling out	• Long inventory financing periods present a key challenge to growth for solar lantern and solar home system distributors • High upfront financing requirements present a key challenge to distributors of larger PV systems (including pumps)
Credit guarantee scheme for inventory financing	• Private sector lending portfolio is de-risked through guarantees and effect loss sharing agreements to cover irrecoverable inventory loans	• De-risking encourages private sector lending to solar sector • Initial security until the proof case of economic viability of lending to solar businesses has been established
Market entry and expansion grants	• Combination of upfront grants and results-based financing to invest in infrastructure and working capital	• Significant upfront investment to build distribution network and source inventories to serve household market
Technical assistance	Solar companies: • Support in setting up technology platforms for PAYG • Incubation and acceleration of early-stage businesses • Capacity building for solar technicians to enable installation and O&M of equipment • Assess rural communities needs to inform the right business model case by case • Capacity building for suppliers in rural areas (supply chain is mainly in Accra)	• Make the business environment more conducive and profitable • Strengthen the overall ecosystem surrounding the solar market • Strengthen capacity across the sector (vs having capacity centralized in Accra only) • Ensure knowledge transfer from abroad for faster, more cost-efficient progress

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

[178] Capacity building interventions are proposed for all ROGEP countries at national and regional level under ROGEP Component 1B: Entrepreneurship support, which includes technical assistance and financing for companies in the solar product value chain. Through this component, technical assistance to solar companies can build on existing ECREEE training programs as well as through a new regional business plan competition. Technical assistance can leverage national solar ecosystem stakeholders, and operational national service providers identified and mobilized through this component. The market entry and expansion grants suggested here would also align with Component 1B planned financing interventions for matching grants, repayable grants, co-investment grants, and be connected to the technical assistance interventions.

2.5 Key Market Characteristics

This section reviews the main characteristics of the off-grid solar market in Ghana, including a summary of key barriers to and drivers of market growth and an overview of gender considerations. The synopsis presented below is largely based on feedback obtained from interviews with local officials and industry stakeholders, as well as focus group discussions and surveys assessing the demand and supply side of the market (see **Annex 2**).

2.5.1 Barriers to Off-Grid Solar Market Growth

Table 46 examines the key barriers to OGS market growth from the perspective of both the demand and supply side of the market. See **Section 1.3.5** for an overview of the gaps in the country's off-grid policy and regulatory framework.

Table 46: Key Barriers to Off-Grid Solar Market Growth in Ghana

Market Barrier	Description
Demand[179]	
Consumers are unable to afford solar systems	• Low-income consumers, particularly in rural areas, lack of access to finance • Purchasing solar products of all varieties among end-consumers remains relatively low.
Lack of initial funding by HHs, businesses and institutions for the initial capital investment	• Relatively high costs of OGS systems (although cheaper in Ghana compared to other countries in the region) • Consumers rather choose cheaper one-off solutions – like generators and fuel – rather than more expensive up-front solutions that will be cheaper long-term (especially with incremental payments, e.g. PAYG)
A lack of understanding of and trust in solar solutions among consumers impedes development of the market	• There is still considerable lack of general awareness about solar solutions • There is an inability to distinguish between solar products or product quality • Consumers lack information about the most suitable design options, funding options, PAYG benefits and options, points of sales and support, etc. • Products are still not widely available in rural areas, so consumers are unfamiliar with them • Any poor history / track record with OGS will deter consumers from taking expensive risks
Informal sector competition and market spoilage	• The non-standard / unlicensed market still accounts for a majority of OGS product sales • Consumers need to understand the quality and value issues of quality solar products vis-a-vis inferior over-the-counter lighting products and generators. Educated consumers drive markets.
Lack of experience in maintaining the systems and sourcing qualified technicians	• A sustainable approach to O&M is critical for long-term success
Supply	
Technical capacity	• Technical skills lack through the supply chain within the sector, affecting both the upstream, midstream and downstream, thus adversely affecting the ability of the sector to pick up and grow. Majority of the firms decry lack of adequate number of technicians to support the downstream side of the market
Transportation costs	• High transportation costs of inventory deter new entrants; devices and equipment are shipped either from China or from Europe, creating long delivery lead times of up to three months and long inventory holding times once products have arrived in country • Typical supplier payment terms are 30% upon placement of the production order and the remaining 70% upon shipment before any cargo has even left its port of origin. • Transport by container would reduce the costs dramatically; however, this requires purchases in bulk, which local solar distributors aren't able to make without financing

[179] The barriers described here apply to some combination of the Household, Institutional, and SME / Productive Use market segments

Poor sales and performance history of the sector	• A lack of investment into the sector prevents growth; this is due to perceived high risks resulting primarily from lack of track record of sales • Solar distributors have limited alternative financing options. Solar suppliers are unwilling to provide trade financing while commercial financiers in Ghana, including banks and MFIs, are currently not positioned to service the financing requirements of solar distributors.
Company finance	• Entrants into the sector require significant working capital, which is not readily available • Equity investments are needed into the local distribution/sales companies. It is quite easy to obtain debt financing and other loans once the solar companies have sufficiently grown and reached the "level of interest" of the larger funds; however, until the number of customers and sales volumes are reached, they need some equity investors to share higher risks with the original founders of the companies
Informal sector competition and market spoilage	• Several informal entrepreneurs have taken advantage of high import duties by illegally importing low-quality solar products ranging from solar lanterns to larger home installations • Black-market traders are able to significantly undercut the prices of registered businesses who are still subject to high taxes and import duties • These products are largely low-grade, failure-prone knock-offs with short product lifespans (sometimes of little more than a few weeks) • Damaged perceptions of solar systems durability and reliability hinders market uptake
Lack of data	• No clear figures on the actual needs, actual usage or experience of consumers • The data for the private market players on the available opportunities is very limited and not concise due to fragmented data
High 'transaction costs' for solar installations	• Cash-flow and bureaucratic hurdles for the local suppliers • Sales and O&M services in remote areas can be costly, especially for small businesses

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

2.5.2 Drivers of Off-Grid Solar Market Growth

Table 47 is a summary of the key drivers of OGS market growth in the country.

Table 47: Key Drivers of Off-Grid Solar Market Growth in Ghana

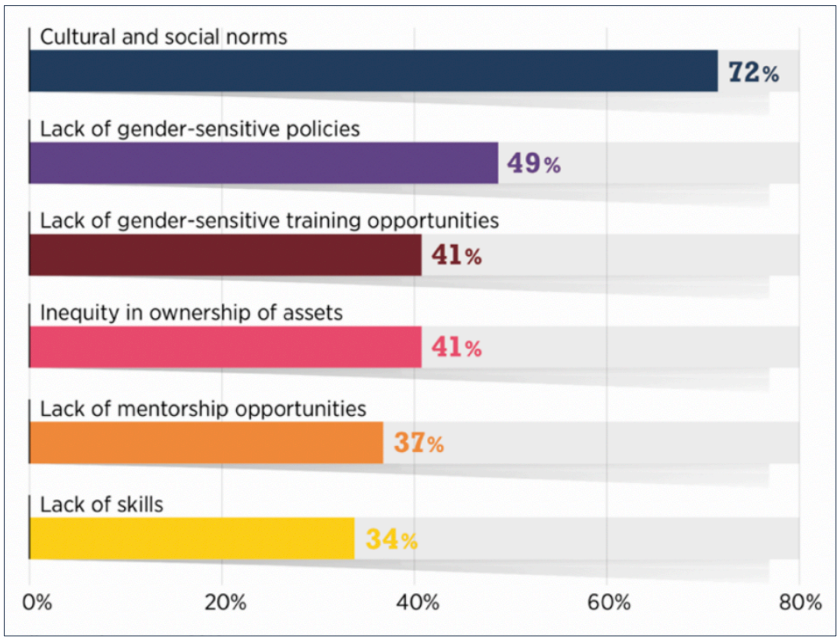
Market Driver	Description
Strong off-grid electricity demand	• Consumers from every market segment are aware of the high costs associated with energy access and consumption and are willing to take on quality, cost-effective alternatives
Willing government to support the industry	• The Government is viewed by sector players as forward- leaning and action-oriented, creating and supporting momentum and positive attention for the solar sector, which helps attract substantial and sustained investment to the market
Increased utilization of PAYG	• Ghana's off-grid market is rapidly growing from the increased utilization of PAYG financing solutions which have successfully leveraged increasing rates of mobile phone ownership and mobile internet usage in rural areas
Engaged and open-minded private sector	• Local OGS suppliers are actively engaged in efforts to improve / reform the sector, accept new business models and strategies and take measures to attract external investment
Strong donor/NGO presence	• The presence and wide range of donor-funded activities in the country's off-grid sector provides confidence that the market will continue to grow

Source: Focus Group Discussions; Stakeholder interviews; African Solar Designs analysis

2.5.3 Inclusive Participation[180]

Given that the off-grid market is only beginning to emerge in Ghana women are not yet highly engaged in the sector. The overall lack of inclusive participation in the off-grid space is attributable to a wide range of factors. In a 2018 survey that assessed barriers to women's participation in expanding energy access, nearly three-quarters of respondents cited cultural and social norms as the most common barrier, which reflects the need for gender mainstreaming (**Figure 43**). More than half of the women surveyed in Africa identified a lack of skills and training as the most critical barrier, compared to just one-third of respondents globally.[181]

Figure 43: Key Barriers to Women's Participation in Expanding Energy Access



Source: International Renewable Energy Agency

As a starting point, electrification (whether grid-connected or off-grid) increases access to information, which can help challenge gender norms and increase the autonomy of women.[182] Access to electricity can save women time and/or enable them to complete domestic activities in the evening, thus allowing them to participate in paid work during the day. Many opportunities also exist for women in the productive use of energy, including solar-powered machinery that can support productive applications, particularly in the agricultural sector in the areas of irrigation, water pumping, and milling/food processing.[183]

Women, who are often the primary energy users in households, have a strong influence on the energy value chain. Women can take on different roles, including as engaged end-users, community mobilizers,

[180] See **Annex 4** for more details.
[181] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[182] "Productive Use of Energy in African Micro-Grids: Technical and Business Considerations," USAID-NREL and Energy 4 Impact, (August 2018): https://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/productive_use_of_energy_in_african_micro-grids.pdf
[183] "Turning promises into action: Gender equality in the 2030 Agenda for Sustainable Development," UN Women, (2018): http://www.unwomen.org/-/media/headquarters/attachments/sections/library/publications/2018/sdg-report-fact-sheet-sub-saharan-africa-en.pdf?la=en&vs=3558

technicians, and part time and full-time employees and entrepreneurs.[184] Women also have unique social networks that typically offer greater access to rural households, which can be important to deploying energy access solutions.

Despite these opportunities, women are typically not part of key decision-making processes and have limited access to land and capital. Women also have more difficulty accessing finance due in part to lack of collateral required to guarantee payment and often resort to obtaining loans from money lenders who charge exorbitant interest rates.[185]

The gender analysis undertaken in Ghana corroborated many of these trends, and revealed several interrelated challenges that women face in the off-grid sector:

- Women lack access to skills, technical capacity, and education/training
- Women broadly lack access to capital, asset ownership, collateral and credit (e.g. to start a business)[186]
- Extensive household responsibilities reduce their ability to generate income and service credit
- Financial literacy among women remains low and there is a lack of education and information available to women on access to financial resources

A number of initiatives exist that seek to address some of these challenges and help improve the rate of participation among women in Ghana's off-grid sector. In 2018, ECREEE partnered with AfDB to launch a regional workshop to advance the participation of women in the renewable energy sector. The program intends to address the lack of inclusion of women in the energy value chain – only 2% of energy sector entrepreneurs in West Africa today are women. The joint initiative ultimately seeks to develop a pipeline of investment-ready, women-owned energy businesses across the region, including in Ghana.[187]

Another key initiative is the *"Women and Solar Entrepreneurship*" Program, which is being implemented by French firm, EDF, in partnership with the Togolese institution, Energy Generation. Under the program, EDF will design training modules that will help equip women with skills needed to set up and repair off-grid solar systems as well as teach them more about entrepreneurship in the clean power sector. Energy Generation will leverage its local knowledge of the West African market to support implementation of the training program at various training centers across the region, with initial beneficiaries from Côte d'Ivoire, Togo and Ghana.[188]

[184] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf

[185] See **Section 3.2** for more details.

[186] This is a huge challenge for women in the country, particularly in rural areas, where the population depends on seasonal income from the agricultural sector for their livelihood, which makes loans inaccessible or only available at extremely high interest rates. This issue is examined in further detail in **Section 3.2.**

[187] "Feasibility study promotes women's participation in energy transition," ESI Africa, (7 May 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

[188] "EDF Teams Up with Energy Generation in West Africa," Alternative Energy Africa, (6 August 2018): https://www.ae-africa.com/read_article.php?NID=9362

III. ANALYSIS OF THE ROLE OF FINANCIAL INSTITUTIONS

This section begins with an introduction to financial products for the off-grid sector, including for end-users and stand-alone solar companies (**Section 3.1**). This is followed by a comprehensive overview of the country's financial market and commercial lending environment (**Section 3.2**), including an assessment of financial inclusion and a summary any off-grid solar lending activity/programs. **Section 3.3** examines other financial institutions (in addition to commercial banks) that are active in the country. **Section 3.4** presents a summary of key findings from the Task 3 analysis. The data presented in this section was obtained through desk research as well as interviews with/surveys of key officials and representatives from local financial institutions. **Annex 3** provides an overview of the Task 3 methodology.

3.1 Introduction to Financial Products for the Off-Grid Sector

A wide range of financial products can be utilized to support development of the stand-alone solar sector in West Africa and the Sahel. These may include instruments such as matching grants, contingent loans, results-based financing (grants reimbursing cost after completion of work), equity investment (seed capital and later stages), concessional debt (subsidized interest or forgiveness of a portion of principal repayment), short-term commercial credits for inventory purchases and working capital, trade finance solutions (from export credit agencies or private trade funders) and medium-term loans secured on assets or receivables from a portfolio of installed projects. This "financial supply chain" consists of capital delivered at different stages of stand-alone solar enterprise development, by financial sector players that have risk appetites well matched to each specific stage. This section focuses on the roles of commercial financial institutions (FIs) and microfinance institutions (MFIs) in providing debt financing to off-grid solar consumers and enterprises.

3.1.1 Financial Products for End-Users

In order to determine what kinds of debt instruments are available to support stand-alone solar purchases for end-users, it is important to identify the different end-users.

- **Households**

Households represent the majority of end-users in the West Africa and Sahel region and the level of cash flow this market segment has available for energy access depends heavily upon the formal and/or informal economic activity they are engaged in. In general, the ability for households to pay from their own internal resources declines as their distance from urban centers increases and their opportunity to participate in the formal economy with regular cash income declines. Meanwhile, external funding is typically not available for rural households as they remain largely off of the radar of mainstream FIs (with the exception of households where members have regular sources of income from urban centers). MFIs in fact are generally more appropriate sources of household finance. Most of a given country's households can access external funding typically only through microfinance or informal financial services such as local money lenders, cooperative societies and rotating savings and credit associations.

- **Public Institutions**

The main public institutional facilities that require funding for off-grid electrification are directly linked to national, provincial or local administrations and budgets, including schools, health facilities, and other public buildings/lighting systems. Sustainable energy finance for community facilities is typically provided through a ministry, department or agency if the facility falls under the purview of the national or provincial

budget. The challenge is that budget resources are severely limited and constantly face competing priorities; as a result, many public community facilities are left without access to energy.

In order to implement financial products targeting public institutional projects, a few critical questions need to be answered, such as who would be the borrower and whether there are sufficient financial resources available in the budget to pay for the service over a long period of time. This question is also important if these public community facilities end up being included alongside households as part of a local mini-grid.

- **Productive Use**

Financial instruments for SMEs as end-users of sustainable energy represent a very important category of products in that they tend to be commercially viable and are thus important for the long-term sustainability of energy systems. While households and community facilities use energy primarily for consumption, often resulting in other sources of income or budget being allocated to cover the cost of service, SMEs use energy for income-generating activities and can therefore cover electricity costs through the income generated by their business. An enterprise with positive cash flows gives financiers more comfort as well as an opportunity to design financial instruments that are commercial in nature. A loan product with parameters that match the company's ability to service the debt would be a strong and commercially viable option. MFIs often provide short-term loans to microenterprises on this basis while FIs often limit their lending to SMEs with strong balance sheets and available collateral.

- **Commercial and Industrial**

Commercial and industrial (C&I) facilities such as industrial plants, mining operations, shopping malls, logistics and distribution centers or commercial office buildings generally have considerable power consumption requiring energy supply from much larger solar systems that can range from several hundred kW to several MW in capacity. Where there is particularly high cost advantage for stand-alone solar systems over existing energy supply (i.e. vs. diesel generators), some C&I facility owners may find the payback of these investments so attractive that they will seek to purchase the solar power plant outright, often requiring debt financing to complete the transaction. This entails a corporate loan backed by the full faith and credit of the company, a pledge on the installed assets and usually supplemented by additional collateral and personal guarantees posted by the C&I facility owners. Many commercial FIs will offer credits to their existing C&I customers for this purpose but the C&I facility loan applicants are often unable or unwilling to post the required collateral for this specific purpose as their assets may already be encumbered for other business needs.

3.1.2 Financial Products for Suppliers/Service Providers

The stand-alone solar sector remains nascent in most markets across West Africa and the Sahel. The companies offering standalone solar products and energy services are therefore often at start-up or early development stage. Overall by number of players, small indigenous entrepreneurs are well in the majority; however, a few international companies dominate the overall market share. Most equipment is imported with purchases denominated in hard currency, while sales to consumers – whether on a direct purchase, Lease-to-Own (LTO) or Pay-As-You-Go (PAYG) basis – are almost always in local currency. At start-up or early stages of operation, local entrepreneurs, although in need of funding, are usually not ready to take on debt financing and should rely more on seed capital investment and grants until they are able to generate an initial book of business. Once orders begin to materialize, these enterprises have growing funding needs suitable for debt financing instruments which may include the following:

- **Working Capital**

All entrepreneurs need working capital to fuel their business growth and cover basic overheads for operations, marketing and sales. Throughout West Africa and the Sahel, there is a dearth of working capital financing for businesses in all sectors, and the situation is no different for stand-alone solar companies. When available, working capital loans have very short tenors of 3-12 months, must be secured on confirmable cash flows, have difficult-to-meet collateral requirements and carry high interest rates. Since their costs and income are in local currency, local entrepreneurs are best served by working capital loans also denominated in local currency. However, due to high cost of local currency debt, many companies will see advantages in borrowing at much lower interest rates in hard currency as the perceived risk of currency fluctuations across such short tenors is relatively low. Some international companies operating in the West African off-grid solar sector may prefer hard currency financing at the offshore holding company level, depending on how they have structured their local subsidiaries or affiliates in the region.

- **Inventory and Trade Finance**

To fulfill orders, solar system providers need inventory on hand. Equipment suppliers to the off-grid sector in West Africa and the Sahel are usually unwilling or unable to offer generous terms, often requiring down payments with balance due in full at cash-on-delivery (COD). Therefore, these businesses are in dire need of short-term loans of 6-12 months duration to finance inventory purchases. Yet, such loans are hard to come by for developing off-grid enterprises. Since equipment purchase arrangements are usually denominated in hard currency, loans also in hard currency over such short tenors are often acceptable. Trade finance from export credit agencies (ECAs) and private trade funders may also provide good solutions, but these lenders are often unwilling to finance orders under a few million USD or EUR in value.

- **Asset-Based or Receivables Financing**

Once stand-alone solar system providers achieve a portfolio of operating PAYG or LTO installations, the system assets and revenues from customer payments can be used to leverage debt financing to fund business activities and expansion. Typically, a Special Purpose Vehicle (SPV) is established to house the asset portfolio, which is sold by the solar provider to lenders. This form of financing has been widely deployed in East Africa and is also increasingly available in West Africa through a variety of regionally focused specialized debt funds that are focused on portfolio financings in the range of USD 1-10 million.[189]

- **Crowd Funding**

Crowd funding platforms have played an important role in offering working capital, inventory financing and smaller increment asset or receivables-backed loans to off-grid entrepreneurs. Loans of two-five years have been provided to both locally-owned and international solar enterprises with a good number of financings in the USD 150-500K range occurring in Nigeria, Ghana and Côte d'Ivoire.[190]

[189] A total of 11 such specialized debt funds was identified, including those managed by: Sunfunder, responsAbility, Lendable, Sima Funds, Solar Frontier, Neot, Deutsche Bank, Triple Jump, Crossboundary, Lion's Head, Shell and Solar Connect. Only a handful of these have vehicles that are fully funded and deploying capital but as of mid-2018 they reported expectations for financial closings that would make roughly USD 1.5 billion in off-grid focused debt available across Sub Saharan Africa by mid-2019.

[190] The most active crowd funding platforms in the off-grid space have been Kiva, TRINE, Lendahand and Bettervest with the latter two most focused on West Africa.

3.2 Financial Market Overview

3.2.1 Market Structure

Ghana has a well-developed financial system which has undergone rapid growth and structural transformation in recent years. The authorities have been implementing reforms to enhance the financial system's resilience to shocks and its contribution to growth. The country's central bank – the Bank of Ghana (BoG) – is the supervisory and regulatory authority in all matters relating to the banking and non-banking financial sector. **Table 48** lists the number and categories of financial institutions regulated by the BoG.

Table 48: Licensed Financial Institutions in Ghana, 2017

License Type	Number of FIs
Deposit Money Banks (DMBs)	34[191]
Rural & Community Banks (RCBs)	141
Non-Bank Financial Institutions (NBFIs)[192]	68
Forex Bureau	417
Microfinance Institutions (MFIs)	566
Inward Money Transfer Companies	5
Credit Reference Bureau	3

Source: Bank of Ghana

Deposit money banks (DMBs) dominate Ghana's financial sector in terms of total assets, deposits and credit as illustrated in **Figure 44**. As of December 2017, the DMBs operated 1,491 branches distributed across the 10 regions of the country and employed 19,730 staff with 2,044 ATMs and 7,356 Point of Sale (POS) terminals.[193] **Appendix 2** includes a summary of key financial indicators for FY 2017 for commercial banks in the country.

In September 2017, as part of reforms to further develop, modernize, and strengthen the financial sector, the BoG increased the minimum paid-up capital of deposit money banks (DMBs) from GHS 120 million (USD 22.8 million) to GHS 400 million (USD 76.2 million) for both existing banks and new entrants. Existing banks had up to December 31, 2018 to restore any capital shortfalls. The RCBs were also required to raise their minimum capital from the GHS 500,000 (USD 95,000) to GHS 1 million (USD 190,000) by the end of 2017. This was the third time in a decade that the sector had witnessed an upward revision of the minimum regulatory capital.[194]

By August 2018, the total number of DMBs in the country had dropped to 30 as the BoG announced it had created a new bank – the Consolidated Bank of Ghana – with GHS 450 million (USD 85.8 million) capitalization to take over selected assets and liabilities of five struggling banks in the country (Sovereign Bank, Royal Bank, The Beige Bank, Construction Bank and Unibank), whose licenses had been revoked mainly due to solvency challenges. The announcement brought the number of Ghanaian banks that have collapsed since 2017 to seven after UT bank and Capital bank were dissolved in August 2017. The

[191] The number of DMBs has significantly reduced to 23 as of January 2019 as a result of consolidation carried out by the BoG
[192] This subsector comprises Savings and Loans Companies (S&L), Finance Houses (FH), and Mortgage Finance and Leasing Companies
[193] Bank of Ghana 2017 Annual Report.
[194] ARB Apex 2017 Annual Report and Bank of Ghana 2017 Annual Report

Consolidated Bank is currently fully owned by the GoG; however, the Government intends to offload its shares in the bank within a period of two years.[195]

In January 2019, the BoG Governor disclosed that only 23 banks met the new minimum capital requirement by the December 2018 deadline. The BoG withdrew the licenses of Heritage Bank and Premium Bank, and the license of GN Bank was downgraded to a Savings and Loans license, while other smaller banks entered in mergers/acquisition.[196]

[195] "BOG Creates Consolidated Bank to take over 5 struggling banks," My Joy Online, (1 August 2018): https://www.myjoyonline.com/business/2018/August-1st/breaking-bog-creates-consolidated-bank-to-take-over-4-struggling-banks.php and https://www.bog.gov.gh/privatecontent/Public_Notices/FAQ%20-%20Consolidated%20Bank.pdf

[196] Dontoh, E., "Ghana Settles Banking Cleanup as Most Lenders Meet New Demands," Bloomberg, (January 4, 2019): https://www.bloomberg.com/news/articles/2019-01-04/ghana-settles-banking-cleanup-as-most-lenders-meet-new-demands

Figure 44: Banking Sector Assets and Liabilities (GHS million)

	2016					2017						
	DMBs	NBFIs	RCBs	MFIs	TOTAL	DMBs	NBFIs	RCBs	MFIs	TOTAL	CHANGE	%
	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	GH¢M	CHANGE
TOTAL ASSETS	82,644.00	9,560.54	3,052.76	1,272.01	96,529.30	93,627.41	12,146.84	3,643.96	1,286.50	110,704.71	14,175.41	14.69
Cash and Bank Balances	22,316.18	1,094.09	413.59	294.63	24,118.49	24,308.83	1,406.14	452.29	382.57	26,549.83	2,431.34	10.08
Investments	22,903.80	2,650.49	1,150.05	47.98	26,752.31	28,607.69	3,343.32	1,414.57	33.45	33,399.03	6,646.72	24.85
Loans & Advances	31,229.18	4,337.25	988.94	535.94	37,091.31	31,568.71	5,321.72	1,160.91	554.17	38,605.51	1,514.20	4.08
Other Assets and PPE	6,194.84	1,478.71	500.17	393.46	8,567.18	9,142.17	2,075.65	616.19	316.31	12,150.32	3,583.14	41.82
LIABILITIES AND SHAREHOLDERS'												
FUND	82,644.00	9,560.54	3,052.76	1,272.01	96,529.30	93,627.41	12,146.84	3,643.96	1,286.50	110,704.71	14,175.41	14.69
Liabilities	71,660.01	8,434.13	2,646.82	1,002.37	83,743.33	81,356.01	10,712.36	3,165.76	1,098.53	96,332.66	12,589.33	15.03
Deposits	52,690.15	5,758.54	2,381.76	686.98	61,517.43	58,209.34	6,943.56	2,880.89	741.39	68,775.18	7,257.75	11.8
Borrowings and other Liabilities	18,969.85	2,675.60	265.06	315.39	22,225.90	23,146.67	3,768.80	284.87	357.14	27,557.48	5,331.58	23.99
Shareholders' Funds	10,983.99	1,126.40	405.94	269.64	12,785.97	12,271.40	1,434.48	478.21	187.98	14,372.07	1,586.10	12.41
Paid-Up Capital	3,995.70	997.83	126.46	327.98	5,447.96	4,579.10	1,233.49	169.26	288.6	6,270.45	822.49	15.1
Reserves	6,988.29	128.57	279.48	-58.34	7,338.01	7,692.31	200.99	308.94	-100.63	8,101.61	763.6	10.41

Source: Bank of Ghana

Table 49: Commercial Bank Financial Indicators (GHS million), 2017[197]

Indicator	Fidelity	UBA[198]	HFC Bank	BoA	BSIC	First Atl.	GTB	UMB	Zenith	Stanbic	Ecobank	Heritage	CAL Bank
Total Assets	5391	217.4	2,100	1343	669	1703	1874	2986	4670.9	5264	9,098	326.8	4223
Net Assets	543.0	40.3	242.2	188.2	125.4	230.2	335	212.3	747.3	917.7	1,036.9	103.1	672.1
Liquidity ratio (%)	215%	NA	119.3%	NA	NA	88%	NA	71%	150%	84.7%	36.9%	NA	125%
CAR (%)	27%	NA	22.1%	16.9	10.5%	23.4%	29.2%	10.2%	25%	23.9%	13.8%	48%	21.9%
NPL ratio (%)	16%	NA	25.2%	18.8	43.2%	18%	19.9%	17%	7.1%	11.6%	15.3%	0%	10.9%
No. of Branches	75	NA	17	NA	NA	NA	NA	NA	NA	39	67	NA	NA
Headcount	1045	NA	NA	NA	NA	NA	NA	NA	NA	811	NA	NA	NA
Operating Income	536.5	47.9	272.8	122.1	58.5	141.9	230.1	287.3	425.2	681.2	1,116.9	20.7	462.2
Operating Expense	323.3	23.1	203.3	80.1	46.8	107.8	104.1	188.9	167.3	315.5	585.3	53.5	188.4
Profit Before Tax	141.8	22.4	69.4	33.3	7.9	28.8	127.5	68.7	250.5	308.9	358.4	-33.7	218.9
Profit After Tax	95.7	15.6	46.5	23.9	7.9	19.8	88.2	47.6	172.6	216	253.7	-26.9	152.9
Customer Deposits	3852.7	152.1	1,712.6	884.7	406.9	1379	1467	1,948.9	3473.4	3,361.2	6,541.7	146.5	2428.2
Loan loss expense	71.4	2.4	-0.02	8.7	3.8	5.2	1.5	29.8	7.5	53.7	173.9	1	55
Cost-to-Income (%)	60.3%	48.2%	74.5%	65.6%	80%	76%	45.2%	65.8%	39.3%	46.3%	52.4%	258%	40.8%
Loan-to-Deposit (%)	27.7%	53.0%	41.1%	56%	68%	18%	27%	37.5%	23.2%	55.8%	41.1%	14.7%	76.3%
Return on Assets (%)	3.0%	9.2%	3.5%	2.7%	1.3%	1.8%	7.5%	2.4%	6.2%	5.9%	3.0%	14.2%	3.6%
Return on Equity (%)	27.3%	69.9%	35.6%	18.9%	6.5%	13.2%	41.3%	36.5%	37.9%	27%	25.4%	28.9%	22.8%

Indicator	ADB	GCB	ARB Apex	Omni	Baroda	Premium	Energy	Access	Barclays	FNB	SC	SG
Total Assets	3545	9,627	326.4	657.7	388.2	1338.1	392.6	3199.8	5,954	260.3	4777	2790
Net Assets	479	1,214	29.2	103.1	166.9	118.5	73.3	469.8	1,052.5	137	920.8	518.9
Liquidity ratio (%)	144.2%	81%	NA	306%	172%	118%	131%	86.8%	NA	17.1%	76.1%	NA
CAR (%)	13.7%	24%	19.1%	24.8%	76%	9.2%	26%	13.3%	20.5%	93%	26%	15.5%
NPL ratio (%)	42.9%	11%	NA	13%	1.7%	46.9%	42%	32.3%	13.6%	0%	35%	13.3%
No. of Branches	78	NA	NA	29	NA	NA	NA	NA	NA	NA	NA	NA
Headcount	1179	NA	NA	NA	NA	NA	NA	NA	NA	128	NA	NA
Operating Income	406.9	1,127	48.9	46.9	44.9	47.2	31.1	270.4	887.3	33.1	676.8	385.6
Operating Expense	309.7	756.9	46.7	47.6	6.4	49.4	28.1	170.9	319.6	60.3	245	219.6
Profit Before Tax	47.3	332	2	-16.9	37.5	-12.2	-2.2	58.6	550.3	-27.4	422.3	127
Profit After Tax	26.5	234.6	4.5	-14.7	25.6	-11.9	-2.7	29.6	386.2	-26.6	283.6	90.5
Customer Deposits	2541	6,924	28	426.2	181.5	443.3	246.9	2131.5	3,161.9	103.4	3,420.2	1,988.3
Loan loss expense	49.8	49.9	0.2	16.3	1	10	5.1	40.8	17.5	0.2	9.5	39
Cost-to-Income (%)	76.1%	67.2%	95.5%	101.4%	14.3%	104.7%	90.4%	63.2%	36%	182.2%	36.2%	57%
Loan-to-Deposit (%)	44.8%	30.3%	106.8%	41%	79%	20.3%	26.5%	41.2%	82%	27.6%	40.5%	70.9%
Return on Assets(%)	1.4%	4.2%	0.7%	-2.9%	11%	-1.1%	0.6%	2.0%	9.8%	10.1%	9.2%	4.8%
Return on Equity (%)	10.1%	29.2%	7.4%	15.3	24.3%	10.1%	2.9%	13.0%	60%	20.1%	50.1%	29.8%

Source: Bank of Ghana

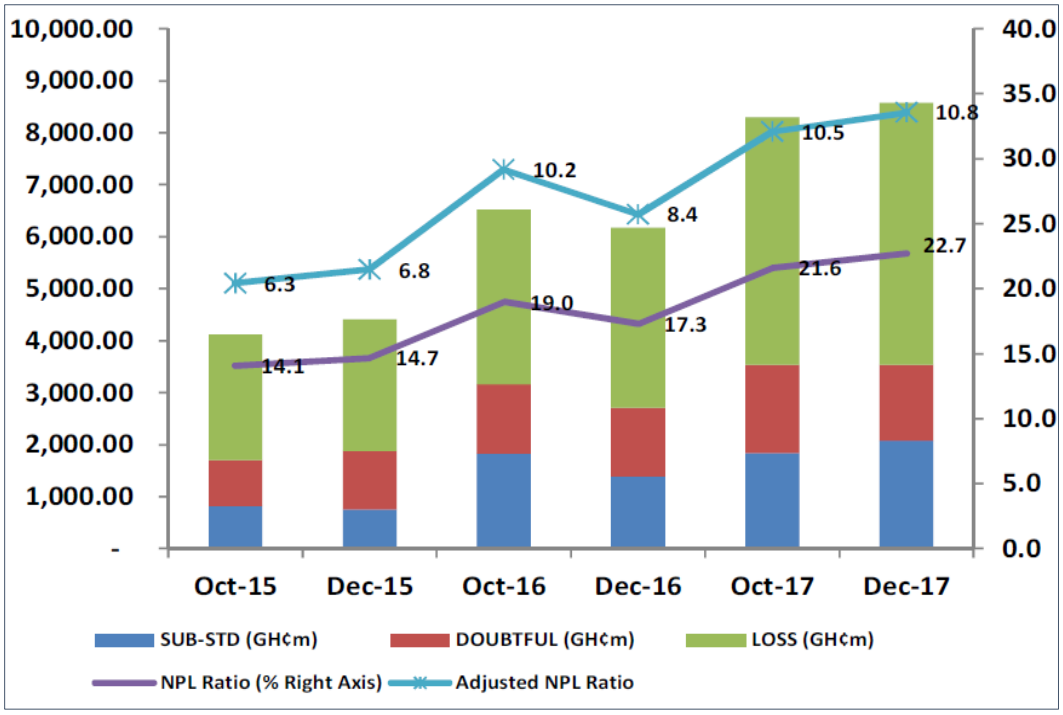
[197] Data obtained from 2017 Annual Reports.
[198] Values in NGN billion

- **Financial Soundness Indicators**

A recent Assets Quality Review of the banking system undertaken by the BoG revealed that there was deterioration in the assets of some banks with high credit concentration in the energy sector. This resulted in additional provisions which impacted negatively on the capital adequacy of some banks. Despite the deterioration of asset quality, the banking sector as a whole continued to be liquid, profitable and solvent.[199]

Asset-Based Indicators: The banks' stock of non-performing loans increased from GHS 6.14 billion (USD 1.1 billion) as December 2016 to GHS 8.58 billion (USD 1.6 billion) in December 2017, translating into an NPL ratio of 22.7% in December 2017, up from 17.3% in December 2016, with over half of these loans in the loan loss category. In addition to the marginal pickup in the year-on-year growth in the stock of NPLs, the increased NPL ratio is attributable to a slowdown in the growth of loans (from 17.6% in December 2016 to 6.4% in December 2017) due to tightened credit stance in response to high NPLs ratio. Adjusting the sector's NPLs for the fully provisioned loan loss category, the ratio stood at 10.8% in December 2017 compared with 8.4% in December 2016 (**Figure 45**).[200]

Figure 45: Banking Sector Asset Quality (GHS million)

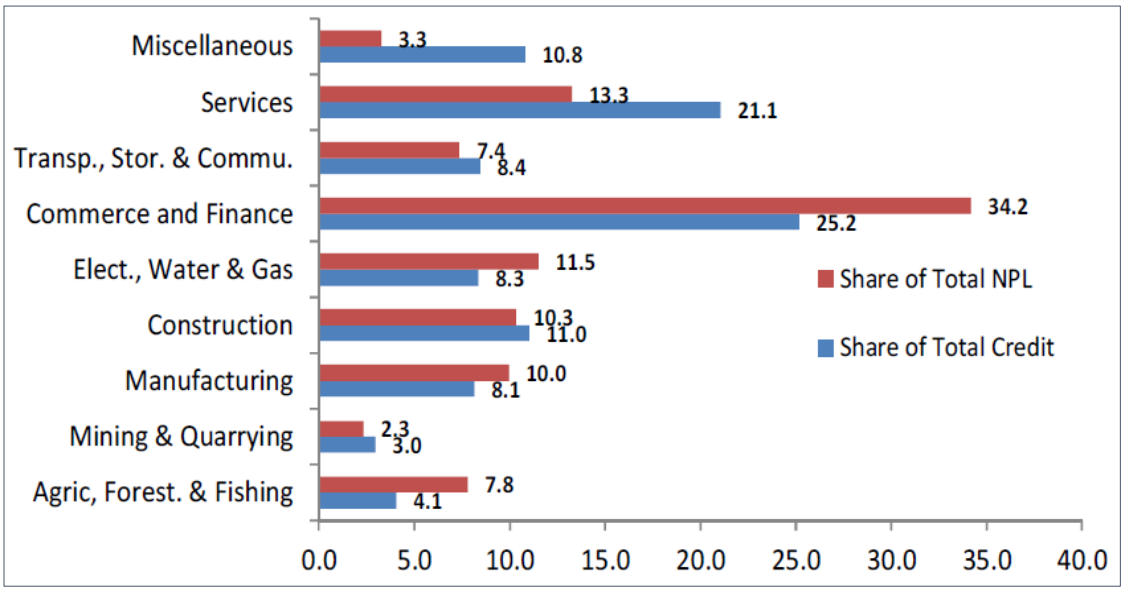


Source: Bank of Ghana

The breakdown of NPLs shows that commerce and finance contributed most to the sector's NPLs, accounting for 34.2% as of December 2017, while the second highest contributor to NPLs was the services sector, accounting for 13.3% in December 2017 **(Figure 46)**.[201]

[199] ARB Apex 2017 Annual Report
[200] Bank of Ghana, Banking Sector Report, 2018.
[201] Bank of Ghana, Banking Sector Report, 2018.

Figure 46: Banking Sector Distribution of NPLs and Credits, 2017



Source: Bank of Ghana

In 2017, the banking sector's operational liquidity indicators recorded a mixed performance as shown in **Table 50** below. Core liquid assets grew by 9.6% between December 2017 and December 2016, while broad liquid assets recorded a growth of 19.7% year-on-year over the same period. Core liquidity measures (core liquid assets to total deposits and core liquid assets to total assets) declined in December 2017 compared with 2016. However, the main broad liquidity indicators (broad liquid assets to total deposits and broad liquid assets to total assets) recorded some improvements during the same period. Despite the decline in the core liquidity indicators, the banking sector remained adequately liquid to meet short-term obligations.[202]

Table 50: Banking Sector Liquidity Ratios

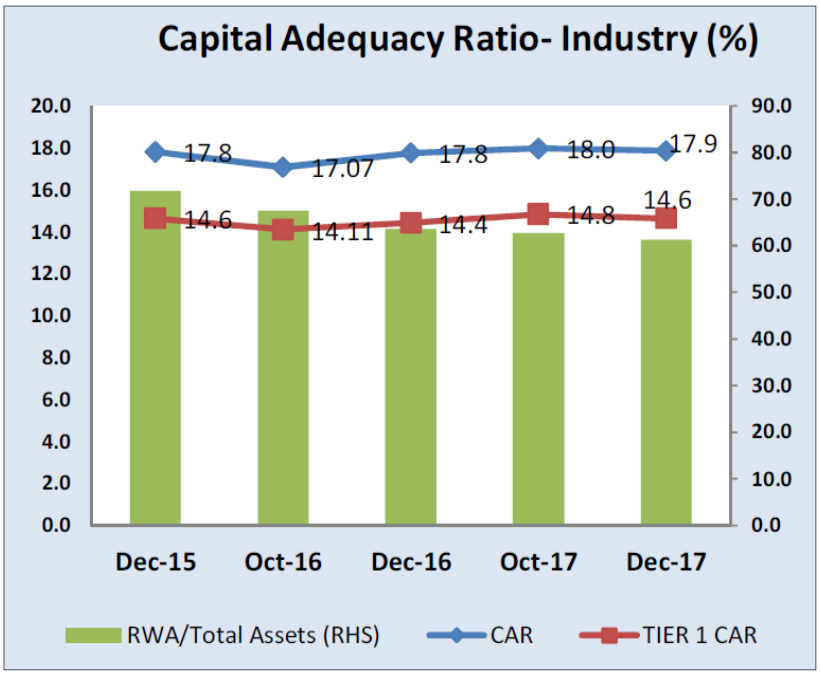
Indicator	Dec-2015	Dec-2016	Dec-2017
Liquid assets (core), GHS million	16,752.6	22,100.9	24,211.64
Liquid assets (broad), GHS million	30,679.4	43,620.3	52,211.49
Liquid assets to total deposits (core), %	40.6%	42.8%	41.5%
Liquid assets to total deposits (broad), %	74.4%	84.4%	89.5%
Liquid assets to total assets (core), %	26.4%	27.2%	26%
Liquid assets to total assets (broad), %	48.4%	53.9%	56%

Source: Bank of Ghana

Capital-Based Indicators: The Ghanaian banking sector remains solvent, with an average capital adequacy ratio (CAR)[203] of 17.9% in December 2017, almost unchanged from 17.8% in December 2016, and above the 10.0% prudential limits (**Figure 47**). The sector's risk-weighted assets (RWA) to total assets was 61.3% in December 2017 compared with 63.7% in December 2016, signifying some moderation in this indicator.[204]

[202] Ibid.
[203] Excluding impaired capital positions of UT Bank and Capital Bank
[204] Excluding UT Bank and Capital Bank

Figure 47: Banking Sector Capital Adequacy Indicators



Source: Bank of Ghana

Profitability Indicators: The banking sector posted a stronger income statement performance in 2017, with net operating income increasing from GHS 4.12 billion (USD 785 million) in December 2016 to GHS 4.58 billion (USD 873 million) in December 2017 due to a slowdown in operating expenses, particularly staff costs. Also, as shown in **Table 51**, the ratio of gross income to total assets (asset utilization) increased in 2017, pointing to an improvement in the income generated from assets. However, the sector's interest spread declined due to lower yields on money market instruments. The banks' interest margin to total assets remained unchanged, while interest margin to gross income declined, reflecting a decline in the proportion of bank's income from interest margin following the decline in money market rates. Also, the banks' after-tax return on equity and pre-tax return on assets both declined in 2017, indicating a decline in the industry's ability to generate more income per unit of equity or assets employed.[205]

Table 51: Banking Sector Profitability Indicators

Indicator (%)	Dec-2015	Dec-2016	Dec-2017
Gross yield	25.7%	26.6%	22.8%
Interest payable	9.8%	11.6%	10.5%
Spread	16%	15%	12.3%
Asset Utilization	18%	17.1%	17.8%
Interest margin to total assets	9%	8.1%	8.1%
Interest margin to gross income	50.1%	47.4%	45.6%
Profitability ratio	15.4%	12.3%	11.5%
Return on equity (%) after tax	22.1%	18%	16.7%
Return on assets (%) before tax	4.5%	3.8%	3.3%

Source: Bank of Ghana

[205] Bank of Ghana, Banking Sector Report, 2018.

- **Sectoral Distribution of Credit**

As a result of the long term structural improvements in the macroeconomic environment, bank credit to the private sector has increased significantly and, with the introduction of the new banking law in 2003, competition among financial institutions has soared.[206] As of end-December 2017, the banking sector's total outstanding credit increased to GHS 37.7 billion (USD 7.2 billion) from GHS 35.4 (USD 6.7 billion) billion in December 2016, although year-on-year credit growth eased due to high NPLs as previously mentioned.[207] As shown in **Table 52**, the share of bank credit to the private sector (comprising loans to private enterprises and households) increased from 85.1% in December 2016 to 91.1% in December 2017. Similarly, credit to households also increased from 13.4% to 15.7%. However, the share of credit to the public sector (comprising central government, public institutions and public enterprises), declined from 14.9% in December 2016 to 8.9% in December 2017, signaling a crowding-in of the private sector.[208]

Table 52: Total Loans and Real Credit Growth Distribution

Indicator	Dec-2015	Dec-2016	Dec-2017
Gross loans and advances (GHS million)	30,102.4	35,409	37,661.8
Real growth (y-o-y)	6.13%	1.89%	(1.32%)
Private sector credit (GHS million)	26,258.6	30,222.1	34,411.3
Real growth (y-o-y)	5.65%	(0.31%)	5.1%
Household loans (GHS million)	4,477.9	4,754.6	5,937.3
Real growth (y-o-y)	(8.2%)	(8%)	16.7%

Source: Bank of Ghana

The private sector credit distribution as of December 2017 is shown in **Table 53**.

Table 53: Private Sector Credit Distribution, 2017

Sector	Share of Total Credit
Commerce and Finance	25.2%
Services	21.1%
Construction	11.0%
Miscellaneous	10.8%
Transport, Storage and Communication	8.4%
Electricity, Gas and Water	8.3%
Manufacturing	8.1%
Agriculture, Forestry and Fishing	4.1%
Mining and Quarrying	3.0%

Source: Bank of Ghana

[206] "Working Finance Work in Africa, Ghana Financial Sector Profile," https://www.mfw4a.org/ghana/financial-sector-profile.html
[207] Bank of Ghana, 2017 Annual Report.
[208] Bank of Ghana, Banking Sector Report, 2018.

3.2.2 Financial Inclusion

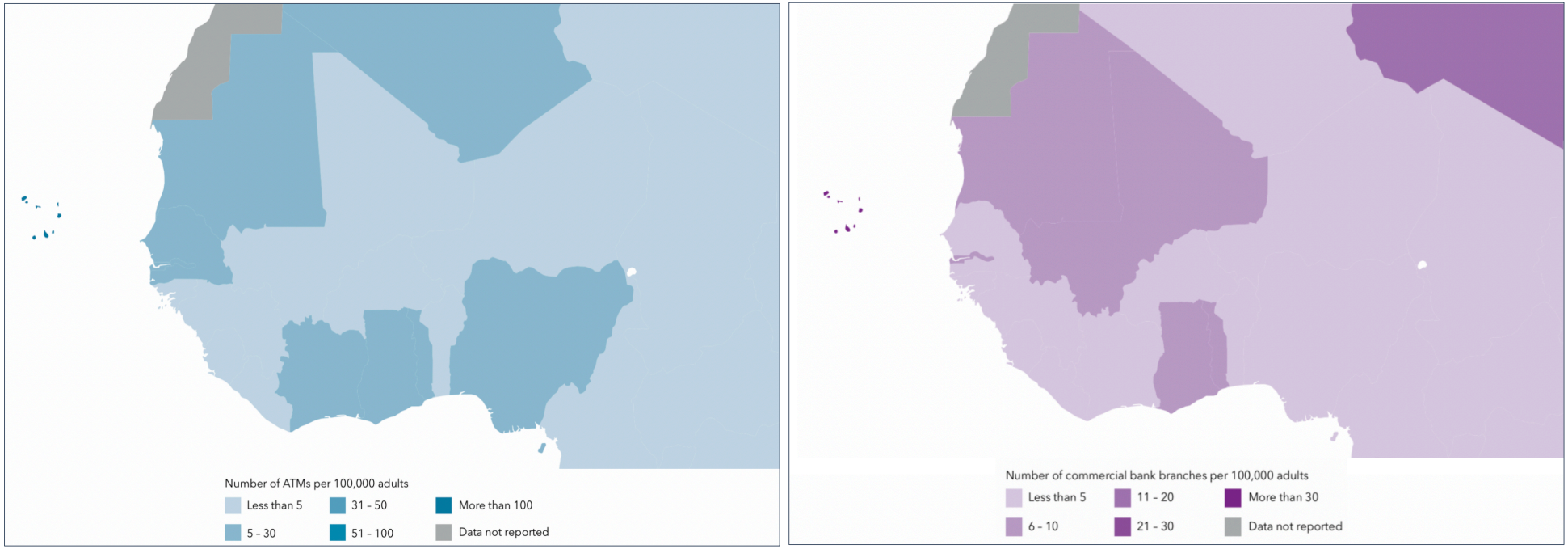
- **Access to Financial Services**

Access to financial services represents an ongoing challenge in West Africa and the Sahel. Overall, about three-quarters of the region's population remains financially excluded, lacking access to banking and financial services through formal institutions (**Figure 48**).[209] There are, however, notable signs of progress. Between 2011 and 2017, the share of the population covered by formal financial institutions increased by nearly 10%.[210] Many countries across the region, including Ghana, have also seen a sharp increase in mobile money account ownership (**Figure 49**) and transaction volume (**Figure 50**).

[209] "Le secteur bancaire en Afrique De l'inclusion financière à la stabilité financière," European Investment Bank, (October 2018): https://www.eib.org/attachments/efs/economic_report_banking_africa_2018_fr.pdf

[210] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., and Hess, J., "The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution," World Bank, (2017): http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf

Figure 48: ATMs and Branches of Commercial Banks per 100,000 Adults in West Africa and the Sahel, 2017[211]

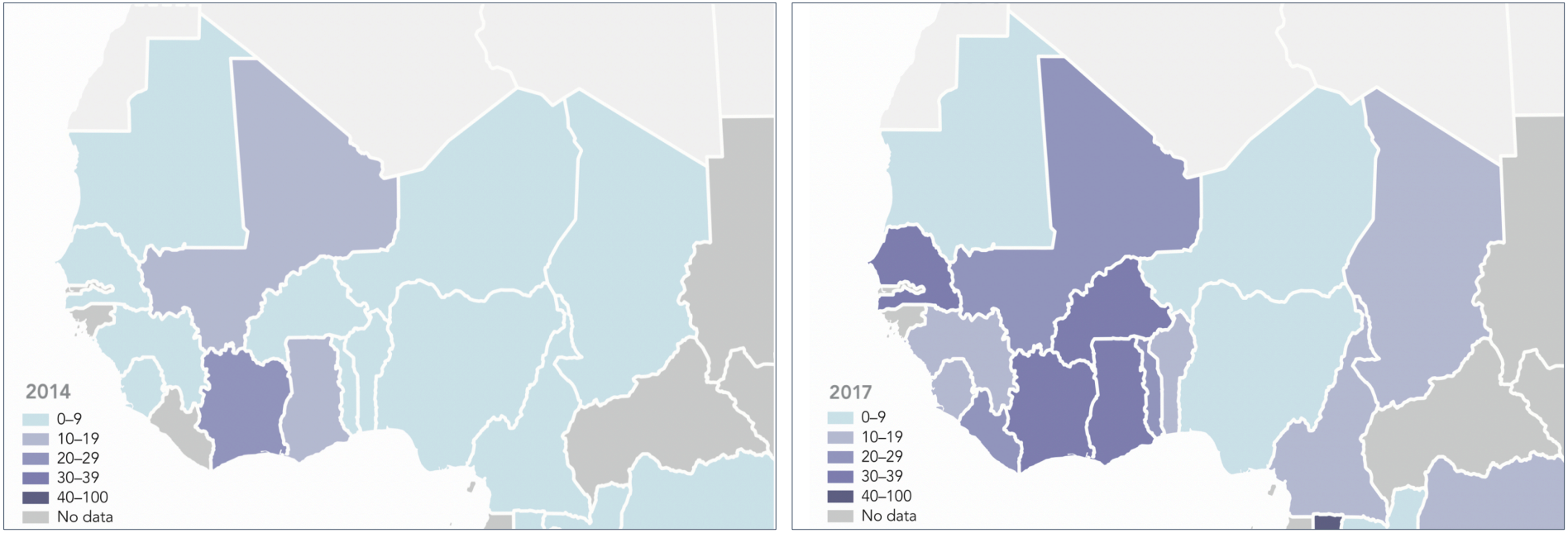


Source: International Monetary Fund

Figure 48 shows the number of ATMs (left) and commercial bank branches (right) per 100,000 adults across West Africa and the Sahel. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. As of 2017, Côte d'Ivoire, **Ghana**, Mauritania, Nigeria, Senegal and Togo had a relatively higher number of ATMs per 100,000 adults compared to the rest of the region, while The Gambia, Ghana, Mali, Mauritania and Togo had a relatively higher number of commercial bank branches per 100,000 adults. Cabo Verde ranked above all countries in the region on both indicators.

[211] International Monetary Fund – Financial Access Survey: http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1460054136937

Figure 49: Share of Adults with a Mobile Money Account in West Africa and the Sahel (%), 2014 and 2017[212]



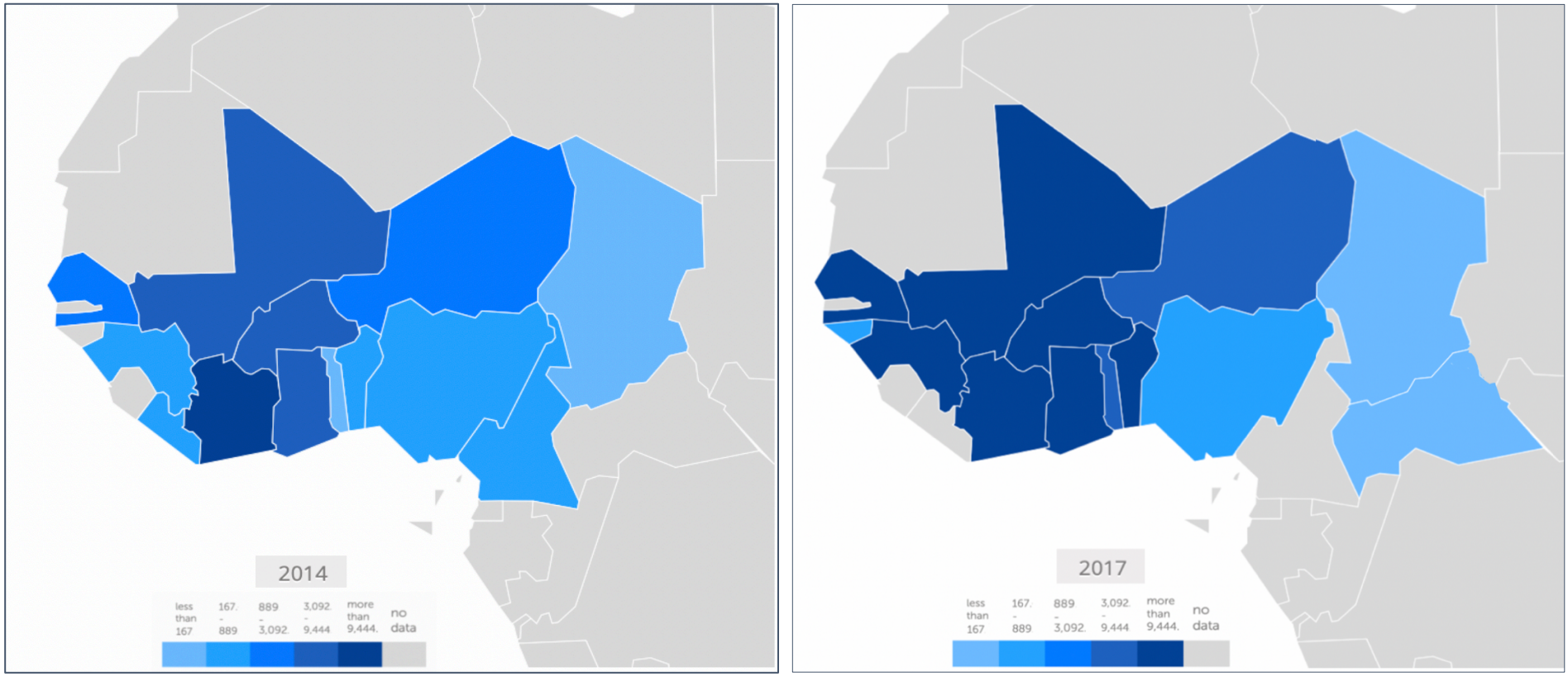
NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

Figure 49 shows the increase in the share of adults (%) owning a mobile money account across West Africa and the Sahel between 2014 and 2017. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. As of 2017, the share of adults owning a mobile money account is about 33% in Burkina Faso, Côte d'Ivoire, and Senegal, and 39% in **Ghana**. Between 2014 and 2017, mobile money account ownership also increased significantly in Benin, Cameroon, Chad, Guinea, Mali, Sierra Leone and Togo, while growth in account ownership was slower in Niger, Nigeria and Mauritania. There was either no data or insufficient data available to assess account ownership in Cabo Verde, Central African Republic, The Gambia, Guinea-Bissau, and Liberia.

[212] Demirguc-Kunt et al., 2017.

Figure 50: Mobile Money Transactions per 1,000 Adults in West Africa and the Sahel, 2014 and 2017[213]



NOTE: Maps exclude Cabo Verde (no data)

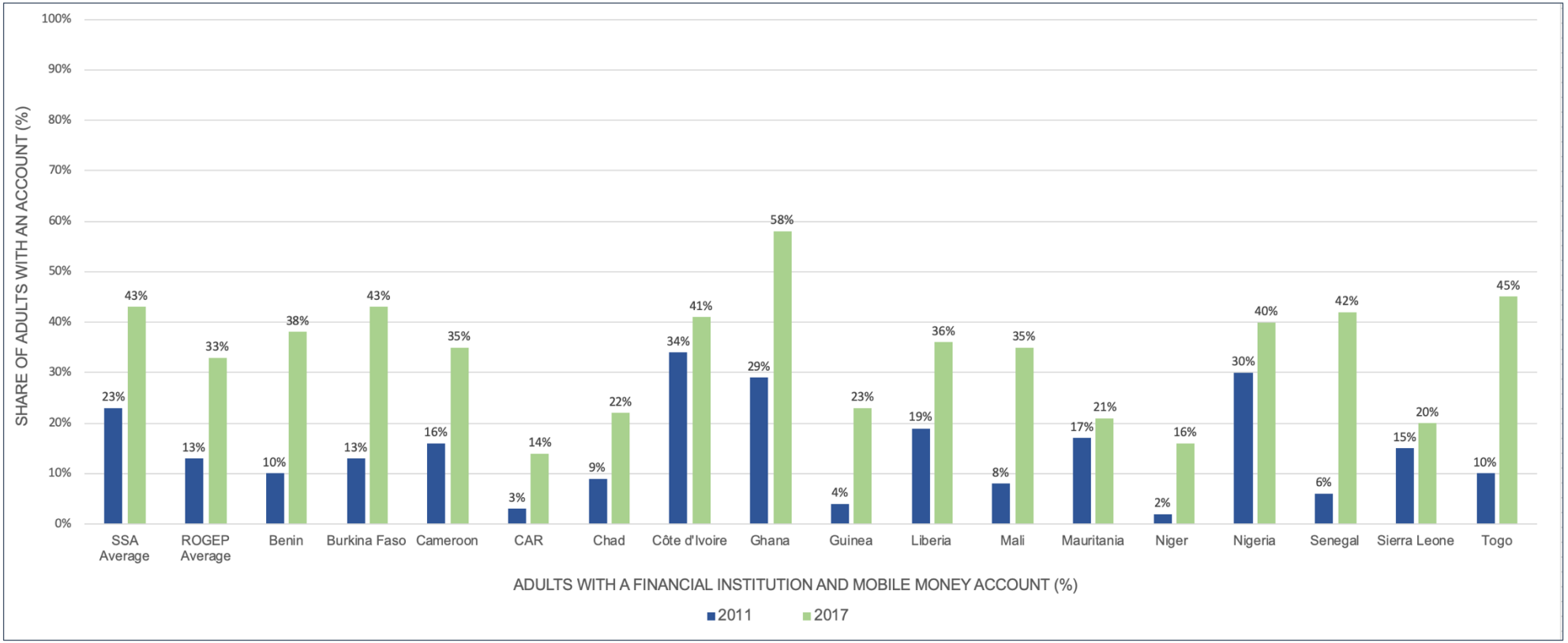
Source: International Monetary Fund

Figure 50 shows the increase in the number of mobile money transactions across West Africa and the Sahel between 2014 and 2017. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. Between 2014 and 2017, mobile money transaction volume increased significantly in Benin, Burkina Faso, Côte d'Ivoire, **Ghana**, Guinea, Mali, Niger, Senegal and Togo, while growth in transaction volume was slower in Nigeria and Chad. There was either no data or insufficient data available to assess transaction volume in Cabo Verde, Cameroon, Central African Republic, The Gambia, Guinea-Bissau, Liberia, Mauritania and Sierra Leone.

[213] International Monetary Fund – Financial Access Survey: http://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C&sId=1460054136937

In 2017, 58% of Ghana's adult population had an account at a financial institution or with a mobile money service provider, up from 29% in 2011. In 2017, the country had the highest rate of financial inclusion in West Africa and the Sahel, 25% above the region's average and 15% above the average for Sub-Saharan Africa (**Figure 51**).

Figure 51: Share of Adults with Access to Financial Services in West Africa and the Sahel (%), 2011 and 2017[214]



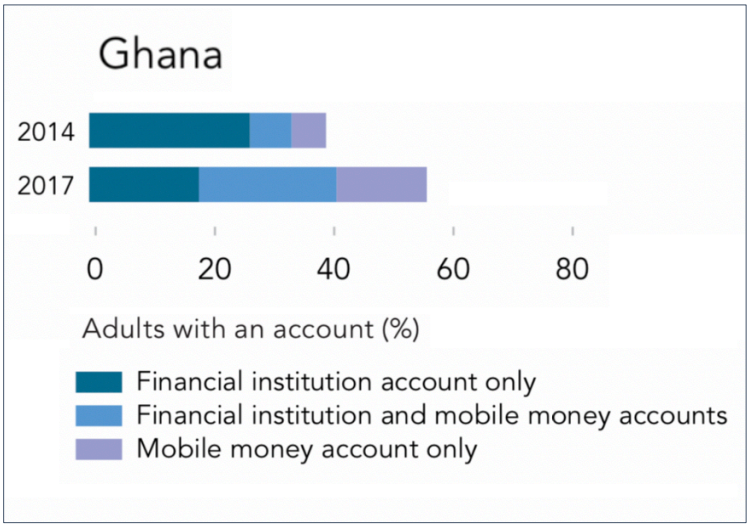
NOTE: Cabo Verde, Guinea-Bissau and The Gambia excluded (no data); data for Côte d'Ivoire is from 2014 and 2017

Source: World Bank Global Findex Database

[214] Demirguc-Kunt et al., 2017.

Financial inclusion has been growing steadily in Ghana, largely due to the growth of digital financial services and an increase in the usage of mobile money accounts.[215] The share of the country's banked population (i.e. with an account at a financial institution and/or with a mobile money service provider), increased from 29% of the population in 2011, to 41% in 2014, and reached 58% in 2017, driven mainly by the proliferation of mobile money services (**Figure 52**).[216] This rapid progress in financial inclusion ranked Ghana among the highest in Sub-Saharan Africa and above all other countries in West Africa and the Sahel.

Figure 52: Financial Institution Account Ownership



Source: World Bank Global Findex Database

The Government of Ghana, which has set a target of increasing the banked adult population to 75% by 2023, is pursuing a national financial inclusion strategy that relies heavily on technological innovation and digital financial services. In July 2015, Ghana passed the Electronic-money Issuers and Agents Guidelines to replace the Branchless Banking Guidelines (2008). This has supported growth in the mobile money space as illustrated in **Figure 53** and **Figure 54**. The number of registered mobile money accounts in 2017 had increased by 21.3% from 2016, while the number of active mobile money accounts increased by nearly 34%. The volume of mobile money transactions increased sharply over the same period, while the total value of mobile money transactions grew by 98.5% to GHS 155.8 billion (USD 29.7 billion) in 2017.[217]

[215] "Ghana Access to Finance Note," World Bank Group, (October 2016): http://documents.worldbank.org/curated/en/956691533058661581/pdf/129096-WP-P151845-Ghana-A2F-Note-PUBLIC.pdf

[216] Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., and Hess, J., "The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution," World Bank, (2017): http://documents.worldbank.org/curated/en/332881525873182837/pdf/126033-PUB-PUBLIC-pubdate-4-19-2018.pdf

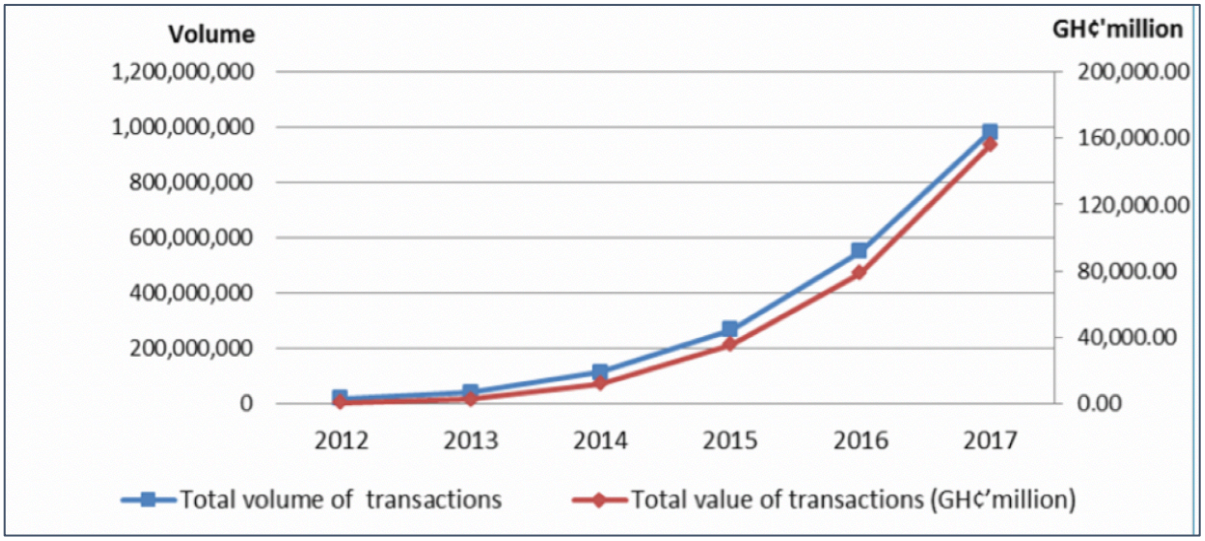
[217] BoG Annual Report 2017; and
"Increased use of mobile money boost financial inclusion in Ghana," Oxford Business Group: https://oxfordbusinessgroup.com/analysis/moveable-feast-expansion-mobile-money-boosting-financial-inclusion

Figure 53: Mobile Money Service Indicators

Indicators	2013	2014	2015	2016	2017	2017 Change	2017 Growth (%)
Total number of mobile voice subscription (Cumulative)[1]	25,618,427	28,026,482	30,360,771	35,008,387	37,445,048*	-860,030	-2.3
Registered mobile money accounts (Cumulative)	3,778,374	4,393,721	7,167,542	13,120,367	23,947,437	4,212,339	21.3
Active mobile money accounts[2]	345,434	991,780	2,526,588	4,868,569	11,119,376	2,806,093	33.8
Registered Agents (Cumulative)	8,660	17,492	26,889	79,747	194,688	57,919	42.4
Active Agents[3]	5,900	10,404	20,722	56,270	151,745	44,330	41.3
Total volume of transactions	18,042,241	40,853,559	113,179,738	266,246,537	981,564,563	431,346,136	78.4
Total value of transactions (GH¢'million)	594.12	2,652.47	12,123.89	35,444.38	155,844.84	77,335.94	98.5
Balance on Float (GH¢'million)	19.59	62.82	223.33	547.96	2,321.07	1,063.67	84.6

Source: Ghana National Communications Authority

Figure 54: Mobile Money Transactions



Source: Bank of Ghana

The country's mobile money sector is led by telecommunications operators (MTN, AirtelTIGO and Vodafone) that are able to leverage their extensive geographic coverage to reach the unbanked segments of the population and acquire new customers at a low cost. The sector is poised to grow even further with the latest mobile money interoperability policy of the Government allowing subscribers to transfer money to different mobile networks domestically. The variety of available services is also expanding and maturing. For example, in 2016, the Bank of Ghana consented to interest payments for mobile banking deposits. Furthermore, the expanding operations of mobile telecommunications companies in the sector are spurring the growth of ancillary services. For instance, TechFin Innovations is set to launch a prepaid card that will be tied to customers' mobile banking accounts. This will extend the range of mobile money accounts, allowing subscribers to pay for goods and services both online and at point of sale, and to withdraw money from ATMs using the card. Such services, based purely on the customer's mobile account, will allow the

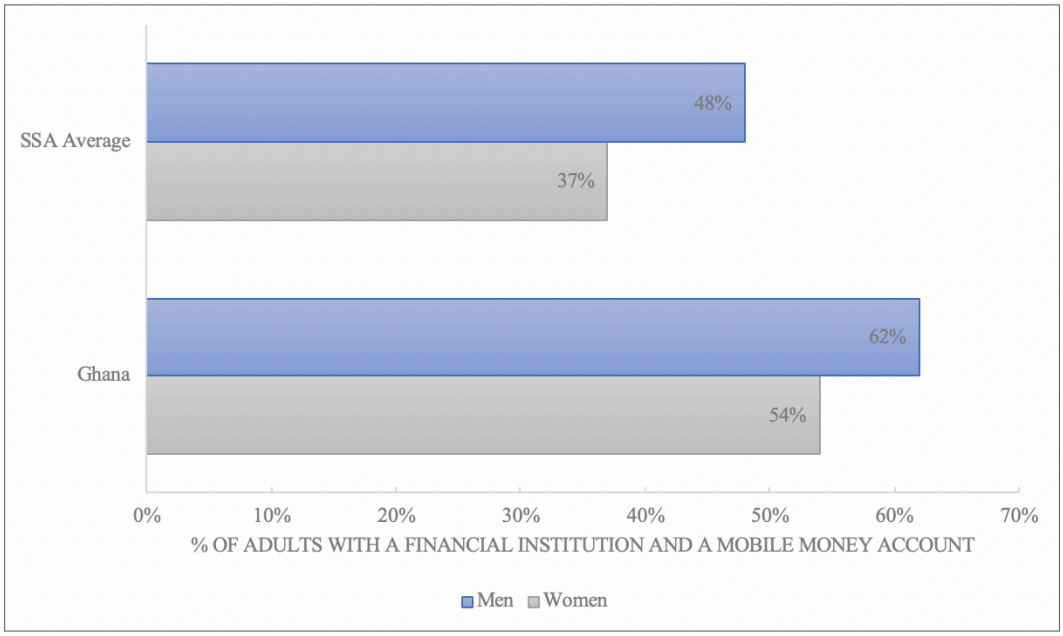
unbanked population to complete a wide range of financial transactions and give them the same opportunity as the banked population.[218]

Widespread mobile phone ownership (**Figure 18)**, rapidly growing mobile internet usage (**Figure 17**) and extensive network coverage (**Figure 40**), have led to the proliferation of mobile money services and platforms in the country. These dynamics are collectively increasing usage of mobile banking services, expanding overall access to financial services and driving financial inclusion in Ghana. Mobile money technology also plays a critical role in the application of off-grid solar solutions, particularly for Pay-As-You-Go systems that rely on the interoperability between digital financial services and stand-alone solar devices.

- **Gender and Women's Financial Inclusion**

Despite the country's overall progress in financial inclusion, there is still a gender gap in access to financial services in Ghana. Data from the World Bank's Global Findex survey examining inclusiveness in the financial sector reveals that women living in Sub-Saharan Africa are on average 10% less likely than men to have an account at a financial institution.[219] While a similar gender gap also exists in Ghana, rates of access to financial services for women (54% in 2017) remain significantly higher than other countries the region and higher than most countries in Sub-Saharan Africa (**Figure 55**).

Figure 55: Financial Inclusion Gender Gap, 2017[220]



Source: World Bank Global Findex Database

Yet, women in Ghana still face various forms of financial exclusion, mainly due to limited access to land and credit. Banks typically require assets as collateral for loans, which makes access to credit difficult for women, who typically do not own land. As a result, women entrepreneurs find it difficult to access finance

[218] "Increased use of mobile money boost financial inclusion in Ghana," Oxford Business Group: https://oxfordbusinessgroup.com/analysis/moveable-feast-expansion-mobile-money-boosting-financial-inclusion
[219] Demirguc-Kunt et al., 2017.
[220] Ibid.

from formal financial institutions to support business growth. Other contributing factors to financial exclusion include social and cultural norms, especially customary practices surrounding land rights,[221] and lower levels of education and rates of literacy among women – while overall adult literacy rates are high (71.5%), only 51.8% of adult women have attained at least a secondary level of education compared to 68.5% of their male counterparts.[222]

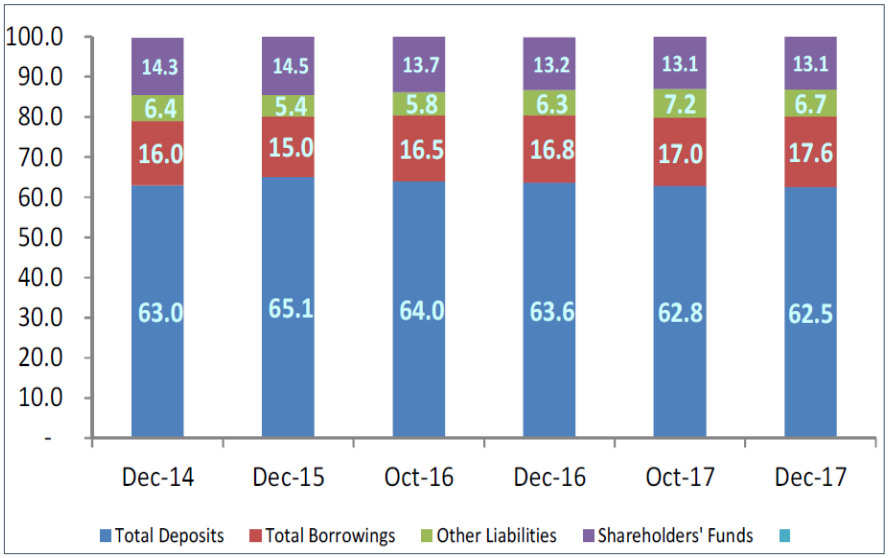
Studies have found that increasing financial inclusion can significantly empower women by increasing savings, reducing levels of inequality, and improving decision-making power in the household. Government programs, policies and regulatory frameworks are therefore critical to overcoming the barriers that women face and driving overall progress towards financial inclusion.[223] The Government has implemented a series of policy and legal reforms to improve gender mainstreaming (see **Section 1.2.2.5** and **Annex 4** for more details).

3.2.3 Commercial Lending Environment

- **Maturity Structure of Bank's Liabilities and Credit**

Total deposits remain the largest source of funding for the Ghanaian banking sector, followed by borrowings. As of December 2017, deposits (mostly short-term) funded 62.5% of the sector's assets while borrowings represented 17.6% (**Figure 56**). A major share of the banks' borrowing is from domestic sources representing 74.4% at end-December 2017 compared to 25.6% of total foreign borrowing. The majority of domestic borrowing is also on a short-term basis as illustrated in **Figure 57**; consequently, the ability of the banks to create long-tenor loans is highly constrained.[224]

Figure 56: Liability Structure of Banks



Source: Bank of Ghana

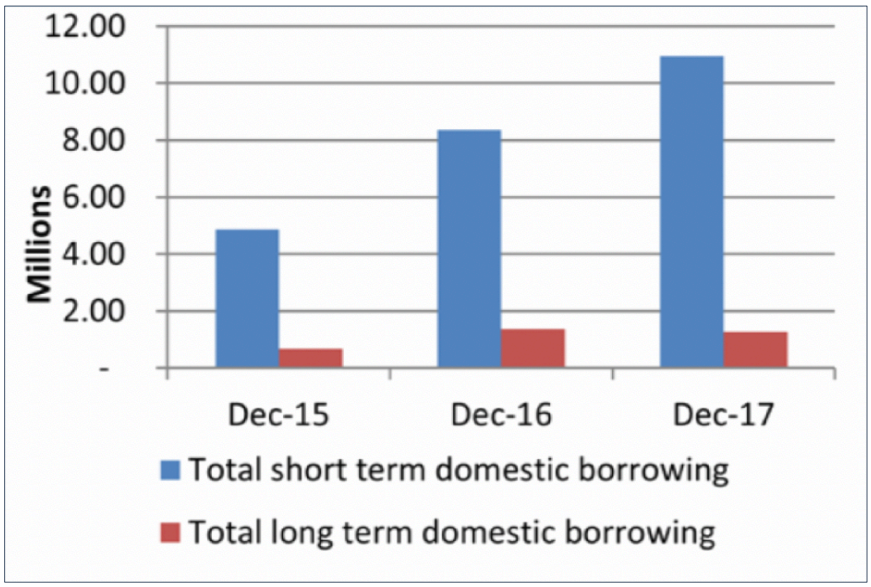
[221] "Ghana: Women struggle to secure land rights," Deutsche Welle, (23 September 2018): https://www.dw.com/en/ghana-women-struggle-to-secure-land-rights/a-45608607

[222] "Human Development Indices and Indicators: 2018 Statistical Update," UN Development Programme, (2018): http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf

[223] El-Zoghbi, M., "Measuring Women's Financial Inclusion: The 2017 Findex Story," Consultative Group to Assist the Poor (CGAP), (30 April 2018): https://www.cgap.org/blog/measuring-womens-financial-inclusion-2017-findex-story

[224] Bank of Ghana, Banking Sector Report, January 2018.

Figure 57: Composition of Bank Borrowing (GHS million)



Source: Bank of Ghana

The bulk of lending remains short term (less than one year), although loan tenors have lengthened in recent years. In 2010, more than 80% of loans had a maturity of 12 months or less and less than 12% of loans had a maturity of 1 to 5 years. However, as of 2014, only 55% of loans had a maturity of 12 months or less while loans with maturity of 1 to 5 years increased to 40%. In addition, the number of loans that mature in more than 5 years has also grown since 2010. The lengthening of loan maturity reflects some diversification in credit products as well as some improvements in the maturity mismatch of assets and liabilities.[225]

- **Interest Rates**

In 2017, interest rates trended downward in response to improved macroeconomic conditions and a cumulative reduction of 550 basis points in the Monetary Policy Rate (MPR) as shown in **Table 54** below.[226] In March 2018, the BOG cut the MPR further by 200 basis points to 18% and further to 17% in May 2018 as inflationary pressures moderated, marking its lowest level since January 2014.[227] The BOG Monetary Policy Committee, during its last meeting in November 2018, maintained the MPR at 17% due to increasing risks to the inflation outlook, although headline inflation fell to an over five-year low of 9.5% in October 2018 and is within the BOG's medium-term target range of 8.0% plus or minus 2.0 % points.[228]

[225] "Ghana Access to Finance Note," World Bank Group, (October 2016): http://documents.worldbank.org/curated/en/956691533058661581/pdf/129096-WP-P151845-Ghana-A2F-Note-PUBLIC.pdf
[226] Bank of Ghana Annual Report 2017
[227] Bank of Ghana, Historical Rate Decisions: https://www.bog.gov.gh/monetary-policy/historical-mpc-decisions
[228] "Monetary Policy Committee Press Release," Bank of Ghana, (November 2018): https://www.bog.gov.gh/privatecontent/MPC_Press_Releases/MPC%20Press%20Release%20-%20November%202018.pdf

Table 54: Interest Rates[229]

Interest Rates	2013	2014	2015	2016	2017	2018
Monetary Policy rate	16%	21%	26%	25.5%	20%	17%
Interbank rate	16.3%	23.9%	25.3%	25.2%	19.3%	16.2%
91-Day treasury bill rate	18.8%	25.8%	23.1%	16.8%	13.3%	13.6%
182-Day treasury bill rate	18.8%	26.4%	24.4%	18.5%	13.8%	14.4%
1-year treasury note rate	17%	22.5%	22.8%	21.5%	15%	15%
2-year treasury note rate	16.5%	23%	23.3%	22.5%	17.5%	19.5%
Average lending rate	25.6%	29%	27.5%	31.2%	29.3%	26.9%
3-month average Deposit rate	12.5%	13.9%	13%	13%	13%	11.5%
Lending - deposit rate spread	13.1%	15.1%	14.5%	18.2%	16.3%	15.4%

Source: Bank of Ghana

In line with the MPR cuts, between 2017 and 2018, the interbank rates and average commercial bank lending rates declined (although still high), while there were marginal increases in the money market interest rates.

Table 55 shows the Annual Percentage Rates (APR) of interest charged on loans and credit advances and the average interest paid on deposits by the individual commercial banks in the country as reported to the BOG as of February 2018.[230]

[229] "Summary of Economic and Financial Data," Bank of Ghana, (November 2018): https://www.bog.gov.gh/privatecontent/MPC_Press_Releases/Summary%20of%20Economic%20and%20Financial%20Data%20-%20November%202018.pdf

[230] "Annual Percentage Rate and Average Interest Paid on Deposits as of 28 February 2018," Bank of Ghana, (March 2018): https://www.bog.gov.gh/privatecontent/Public_Notices/Bank%20of%20Ghana%20releases%20APRs%20for%20February%202018.pdf

Table 55: Commercial Bank Lending Rates, 2018

			HOUSEHOLDS			ENTERPRISES			
	Deposits	Base Rate	Vehicle Loans	Mortgage	Other Consumer Credit	Agriculture	Manufacturing	Commerce	Construction
Banks	Average Interest Rate	Percent	Annual Percentage Rate	Annual Percentage Rate	Annual Percentage Rate	Annual Percentage Rate	Annual Percentage Rate	Annual Percentage Rate	Annual Percentage Rate
Access Bank	9.9	22.8	N/A	N/A	28.1	27.0	26.0	27.8	27.8
ADB Bank	6.5	22.9	32.7	N/A	31.2	28.6	31.2	31.2	31.2
Bank of Africa	10.5	26.2	29.1	28.6	30.6	28.6	29.6	28.6	29.1
Bank of Baroda	14.5	18.63	22.0 - 28.0	22.0 - 28.0	25.0 - 30.0	22.0 - 28.0	22.0 - 28.0	22.0 - 28.0	22.0 - 28.0
BSIC	9.2	26.3	28.0	N/A	28.0	28.0	28.0	28.0	28.0
Barclays Bank	12.4	18.1	N/A	N/A	28.1 - 33.2	22.8 - 32.4	24.0 - 31.4	19.1 - 32.3	24.0 - 30.1
CAL Bank	9.4	27.2	34.1	31.1	34.1	N/A	32.8	32.8	32.8
Ecobank	9.9	26.0	34.1	34.1	N/A	26.5	26.5	28.7	26.5
Energy Bank	6.4	25.4	N/A	N/A	N/A	N/A	32.0	32.0	32.0
First Atlantic Bank	8.8	25.2	NA	NA	33.5	35.3	34.0	29.4	30.2
FBN Bank Ghana	10.0	26.6	31.9	31.9	32.8	N/A	31.7	31.7	31.7
Fidelity Bank	10.0	18.2	NA	30.3	31.0	30.7	30.7	30.7	30.7
First National Bank	10.6	21.5	N/A	N/A	N/A	N/A	N/A	25.6	N/A
GCB Bank	8.2	22.1	30.7	N/A	30.7	26.4	26.4	26.4	26.4
GN Bank	13.3	19.8	32.0	N/A	32.0	26.0 - 32.0	26.0 - 32.0	22.0 - 29.0	26.0 - 32.0
Guaranty Trust Bank	7.3	24.8	N/A	N/A	32.6	N/A	28.5	29.6	30.6
Heritage Bank	8.3	29.6	N/A	N/A	32.3	N/A	N/A	32.1	32.0
HFC Bank	8.4	24.2	29.6	26.2	29.6	31.9	29.2	30.6	30.3
National Investment Bank	11.4	27.8	N//A	N/A	N//A	37.2	37.2	37.2	38.2
Omnibank	14.6	29.3	30.4	N/A	31.9	32.4	32.4	31.9	32.9
Premium Bank	13.6	32.6	32.6 - 36.0	N/A	32.6 - 36.0	32.6 - 36.0	32.6 - 36.0	32.6 - 36.0	32.6 - 36.0
Prudential Bank	10.5	25.2	30.4	30.4	30.4	29.9	30.4	30.4	30.4
Sovereign bank	12.2	32.0	N/A	N/A	N/A	35.9	N/A	N/A	N/A
Standard Chartered Bank	3.3	13.5	N/A	N/A	21.8 - 32.0	21.8 - 32.0	21.8 - 32.0	21.8 - 32.0	N/A
Societe Generale Bank	9.2	18.9	N/A	N/A	N/A	27.7	28.7	32.0	29.7
Stanbic bank	8.9	18.4	24.7	24.7	24.7	24.7	24.7	24.7	24.7
The Royal Bank	11.0	29.4	34.7	N/A	34.7	34.7	34.7	34.7	34.7
United Bank for Africa	10.6	27.9	33.1	NA	31.0	32.9	30.4	32.6	31.7
Universal Merchant Bank	8.0	25.7	NA	NA	34.1	NA	NA	33.7	38.8
Unibank	13.4	33.7	37.8	N/A	34.9	N/A	36.8	36.3	37.1
Zenith Bank	12.0	20.4	26.5	N/A	26.5	26.5	26.5	29.5	26.5
INDUSTRY AVERAGE	10.1	24.5	30.9	28.7	30.8	29.7	29.9	30.1	30.5

Source: Bank of Ghana

➢ Foreign Exchange Market

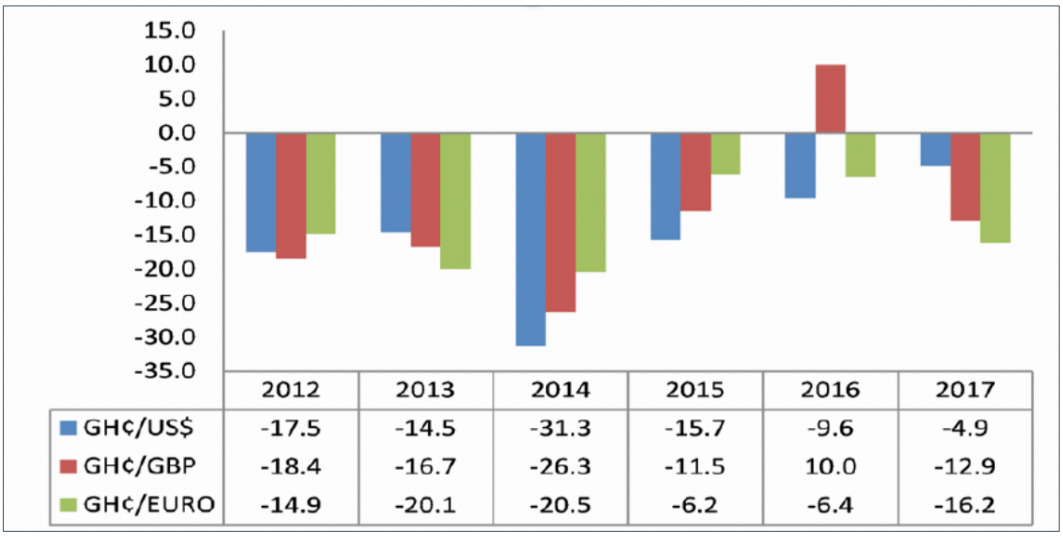
Ghana has a free-floating exchange rate that is determined by the market forces of demand and supply. However, the BoG has the mandate to issue directives and policy guidelines aimed at ensuring discipline in the foreign exchange market. In 2007, the BoG carried out a currency redenomination exercise which saw four zeroes wiped off the national currency. The old currency (cedi) had been rendered almost worthless by years of inflation that hit double digits a year for almost three decades.[231]

Table 56: Official Exchange Rate (GHS-USD)[232]

Exchange Rate	2013	2014	2015	2016	2017	2018
End of Period	2.20	3.20	3.79	4.20	4.42	4.79
Period Average	1.95	2.90	3.67	3.91	4.35	4.49

Source: Bank of Ghana and International Monetary Fund

Figure 58: Interbank Exchange Rate (Year-on-Year Change, %)



Source: Bank of Ghana

Table 56 and **Figure 58** illustrate that the Ghanaian cedi has been depreciating in the past few years, although the depreciation has slowed in the last two years on account of an improved economic outlook. In 2017, the Ghanaian cedi was relatively stable against the US dollar, driven mainly by improved foreign exchange supply. On the inter-bank market, the Ghanaian cedi experienced an annual depreciation of 4.9%, an improvement from the 9.6% and 15.7% recorded in 2016 and 2015 respectively. Similarly, on the Forex bureau market, the pace of depreciation of the Ghana cedi moderated to 6.9% in 2017 from 9.6% in 2016. In 2018, however, the strengthening of the US dollar in the international markets has exerted pressure on currencies in emerging markets and frontier economies, including Ghana. Hence, between January and November 2018, the cedi cumulatively depreciated by 7.8%, compared with 4.6% depreciation in the same

[231] "Macroeconomic Implication of Currency Management in Nigeria: A Synthesis of the Literature," British Journal of Economics, Finance and Management Sciences, (July 2013): http://www.ajournal.co.uk/EFpdfs/EFvolume8(1)/EFVol.8%20(1)%20Article%202.pdf

[232] International Financial Statistics (IMF): http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B; and "Summary of Economic and Financial Data," Bank of Ghana, (November 2018): https://www.bog.gov.gh/privatecontent/MPC_Press_Releases/Summary%20of%20Economic%20and%20Financial%20Data%20-%20November%202018.pdf

period in 2017. In order to stem the growing depreciation of the cedi, the BoG has been intervening in the interbank foreign exchange market by supplying US dollars to meet market demand and its strategy is to continue to intervene in the market to keep the official rate from depreciating further.[233]

- **Collateral Requirements**

Ghanaian banks have high collateral requirements of over 200% of the loan amount for all-sized firms and over 250% for SMEs, compared to the sub-Saharan Africa average of 181%. Also, real property is the most frequent type of collateral required by these banks. This makes access to formal finance virtually prohibitive for many Ghanaian businesses, especially SMEs.[234] In a bid to improve access to credit, in 2010, Ghana became the first country in Africa to set up a secured transactions registry. The collateral registry was established under the Borrowers and Lenders Act (2008) to facilitate access to finance, especially for SMEs, through secured lending. The registry provides services including the registration of charges (secured loans) and collaterals, and provision of avenues for lending institutions and the general public to conduct searches on registered charges and collaterals. It also assists in speeding up realization of collaterals upon default by a borrower and in effecting discharges of registered charges and collaterals upon application by registrants.[235]

The collateral registry has been fully web-based since June 2012 and as of October 2016 it had secured the tracking and analysis of USD12 billion in financing using movable assets as collateral through more than 75,000 loans (originated both before and after the Registry was launched); 80% of these loans were granted to individuals/micro-entrepreneurs and 15% to SMEs. Around 30,000 registrations valued at USD100 million were made by women entrepreneurs. In addition, Table 2 below shows there has been a steady increase in the number of charge registrations, collaterals and searches conducted to ascertain the status of assets on the registry. A total of 171,551 collaterals were registered in 2017, compared with 129,782 in 2016. Collaterals registered in 2017 comprised 44,933 equipment and machinery, 41,118 household assets, and 38,918 inventory/account receivable. The remaining collaterals were 15,571 investment property, 10,655 motor vehicles, 9,008 real estate property, 3,760 business assets and 7,588 collaterals were not classified. The number of institutions that registered charges in 2017 totaled 368 compared to 255 recorded in 2016. These were made up of 111 MFIs, 99 RCBs, 33 DMBs, 57 NBFIs, 21 microcredit companies and 24 other companies. The remaining were 12 Investment firms, eight foreign banks and two financial NGOs. However, despite the success recorded thus far, specific regulatory gaps and operational challenges still have to be addressed for the efficient operation of the collateral registry.[236]

Table 57: Collateral Registry Key Indicators

Indicator	2014	2015	2016	2017
Registrations	23,662	25,216	43,504	57,509
Collaterals	57,012	59,680	129,782	171,551
Searches	6,820	7,849	16,064	25,049

Source: Bank of Ghana

[233] Bank of Ghana Annual Report 2016
[234] "Ghana Access to Finance Note," World Bank, (October 2016): http://documents.worldbank.org/curated/en/956691533058661581/pdf/129096-WP-P151845-Ghana-A2F-Note-PUBLIC.pdf
[235] "Collateral Registry, Improving Access to Credit," Bank of Ghana: https://www.collateralregistry.gov.gh/Home/About
[236] Bank of Ghana Annual Report 2017

3.2.4 Lending to the Off-Grid Solar Sector

Relatively high real interest rates, large collateral requirements, and the short tenor of typical loans offered by local banks hamper financing of the off-grid solar sector in Ghana. Hence, most OGS projects have been carried out with the assistance of donor agencies and/or DFIs. Participants in the focus group meeting held in Accra in 2018 stressed that the Ghana Energy Development and Access Project (GEDAP)[237] has been a major contributor to the financing of the OGS market in the country. In 2009, the Global Partnership on Output-Based Aid (GPOBA) approved a USD 4.35 million grant to support the installation of SHSs and PV lanterns for 15,000 households in off-grid areas. The project was part of the renewable energy component of the GEDAP, complementing its focus on grid extension. Under the project, GPOBA provided subsidies to approved service providers of 50–60% of the total cost of the systems while users paid the remaining 40–50% of costs through loans for the SHSs and out-of-pocket for lanterns.

In financing the SHSs, GPOBA partnered with ARB Apex Bank, which serves as a mini-central bank for RCBs in the country. ARB Apex Bank managed an IDA-supported line of credit to refinance 80% of loans from 12 participating rural banks for their clients to purchase the SHSs, while RCBs contributed the remaining 20%. The RCBs offered consumers three-year tenor loans at 29% interest rate. The project exceeded its targets, as approximately USD 1.6 million in consumer loans were accessed through the RCBs, resulting in the deployment of 8,831 SHSs and 7,991 lanterns for 16,500 households in remote, off-grid areas. Seven of the 12 participating RCBs had a 98% or higher repayment rate with an overall loan recovery rate of 78%.[238] In addition, under the first phase of the UN Environment's African Rural Energy Enterprise Development (AREED) program (2000 - 2008),[239] E+Co provided loans ranging between USD 50,000 to 2 million to clean energy businesses/entrepreneurs at an average interest rate of 29%.[240]

While large international companies operating in the country have access to loans, equity and other international funds to finance their growth and development, many local companies are unable to raise funds to expand their business. Local banks are extremely conservative with regard to solar enterprises as most of these companies have weak balance sheets. However, with support from donor programs, some local commercial banks are beginning to express interest in lending to the sector. A number of these banks, including UMB, UniBank, and afb Ghana, have recently launched special solar facilities while several others have certain hire purchase credit facilities for off-grid solar systems.[241]

[237] GEDAP is a USD 220 million multi-donor project involving the World Bank's International Development Association, Global Environment Facility, African Development Bank, Global Partnership on Output Based Aid, Africa Catalytic Growth Fund and the Swiss Agency for Development and cooperation

[238] "Policy Report Note Ghana," Lighting Africa / IFC, (2012): http://www.ecowrex.org/system/files/documents/2012_policy-report-note-ghana_lighting-africa-ifc.pdf; and
"Improving Rural Energy Access through solar Home Systems in Ghana," GPOBA, (June 2016): https://www.gpoba.org/sites/gpoba/files/LL12_GhanaSHS.pdf

[239] The African Rural Energy Enterprise Development (AREED) program was founded on the idea that the delivery of clean energy services by small and medium-sized enterprises can transform the lives of impoverished people, helping them to break out of the vicious circle of poverty. The program seeks to expand energy access by helping people in rural Senegal, Mali, Ghana, Tanzania and Zambia start income-generating ventures using modern, clean, and reliable energy technologies.

[240] "Policy Report Note Ghana," Lighting Africa / IFC, (2012): http://www.ecowrex.org/system/files/documents/2012_policy-report-note-ghana_lighting-africa-ifc.pdf

[241] "The National Rooftop Solar Programme," National Rooftop Solar Programme, (April 2017): https://www.transparency-partnership.net/sites/default/files/u2612/1-the_national_rooftop_solar_programme_ghana_appiah_25.04.17.pdf

3.2.4.1 Programs Supporting Financial Institutions in Off-Grid Solar Lending

- **USAID Climate Economic Analysis for Development, Investment, and Resilience (CEADIR)**

The CEADIR engagement in West Africa took place from 2016 to 2018. The program's objective was to strengthen the capacity of FIs for clean energy lending in eight West African countries (Côte d'Ivoire, Ghana, Guinea, Liberia, Niger, Nigeria, Senegal and Sierra Leone) addressing their common challenges by developing the capacity of bank staff to provide loans for various clean energy technologies and business models and adapting their support to the specific context each country. CEADIR supported local banks by delivering a national workshop on stand-alone solar and mini-grids, which was complemented with one-on-one technical assistance to help banks develop clean energy lending strategies.[242]

A total of seven banks in Ghana participated in the program – Royal Bank, Ghana Home Loans, Heritage Bank, Stanbic, UT Bank, CAL Bank, HFC Bank – out of the 31 commercial banks in the country at the time. CEADIR complemented these workshops with one-on-one technical assistance tailored to the needs of the FIs. Two local FIs, namely Heritage Bank Ghana and Stanbic Bank Ghana, prepared a bank diagnostic to identify topics for one-on-one technical assistance. Accordingly, CEADIR worked with both institutions to support development of clean energy lending strategies as detailed below.[243]

Heritage Bank: The bank diagnostics carried out under the program revealed that Heritage Bank required support in developing green loan products, understanding the potential risk associated with clean energy lending and accessing alternative funding options with low interest rate for on-lending and longer tenors. Accordingly, CEADIR conducted an in-depth strategy and business planning multi-day session with the bank, including review of the bank's existing product lines to identify what could be used to finance clean energy projects and businesses. CEADIR helped Heritage Bank design a program through which the bank would certify clean energy companies as approved vendors, who could provide clean energy services to the bank's clients, thus, effectively creating new deal flow for the bank and allowing the approved vendor to tap into a new customer base. Heritage Bank decided to pilot the program with KATA Solar, which offers rooftop solar installations to C&I and residential users in Ghana. Heritage also decided to use the existing credit and risk policy of the bank during the initial phase of lending, with plans to update the policy documents based on experience gained through clean energy finance. The bank explored a finance model through which it would collateralize the asset being financed and extend a facility to the client. The bank also identified potential corporate clients who might be interested in clean energy solutions and outlined marketing efforts to those clients. One of the potential clients identified by Heritage Bank was seeking debt funding to undertake a solar street-lighting project in the Western Region of the country, with the Government of Ghana as the off-taker.

CEADIR also worked with Heritage Bank to outline its approach to penetrating the market, forming the basis for the bank's clean energy business plan. The Heritage Bank team mapped out next steps, including completion of the business plan, conclusion of a vendor agreement for consumer and asset finance, and conclusion of loans for rooftop solar installations. CEADIR also helped Heritage Bank develop and refine a product concept paper for a "green loan" program as part of the bank's larger strategy. The resulting Heritage Green Loan product was designed to offer loans to bank customers who are employees of approved institutions, for principals of up to GHS 50,000 (USD 9,500) to finance installation of residential solar or biogas systems implemented by approved vendors. The product included a mechanism for tracking any 'green lending' to create a distinction between the core lending and green lending transactions, which

[242] USAID CEADIR: https://www.climatelinks.org/resources/renewable-energy-lending-west-africa
[243] "Market Assessment Report on Clean Energy: Ghana," USAID Climate Economic Analysis for Development, Investment and Resilience (CEADIR), (June 2018): https://www.climatelinks.org/resources/renewable-energy-lending-west-africa

would be useful for accessing financial resources such as the Green Climate Fund. CEADIR also trained bank staff to identify funding sources and develop strong applications for future donor-funded products.[244]

Stanbic Bank: The bank diagnostics conducted under the program revealed that Stanbic Bank required capacity building to assess clean energy projects, clean energy product structuring and development, and selection of developers as vendors. Accordingly, CEADIR conducted a workshop for Stanbic Bank with participants from four departments within the bank – credit, risk, corporate and product development – to address the question of how to manage repayment risk and helped the bank prepare a roadmap for developing rooftop solar loan products for project developers and end-users. The concept is very similar to that of Heritage Bank (described above). The roadmap is currently undergoing an internal approval process. Stanbic Bank's product development team indicated the bank would commence with rooftop solar for both residential and commercial purposes. The team confirmed that management is also reviewing the product development department's request to have a working relationship with KATA Solar.

Stanbic also envisions the roll-out of a green mortgage product once the rooftop solar product is successfully implemented. In addition, as part of the process of identifying approved vendors, the CEADIR team requested invoices from four developers (Wilkins Engineering, KATA Solar, Translight, and Sun Power Innovation) to compare prices and make appropriate recommendations. CEADIR also advised the bank on sources of available financing with suitable terms for on-lending.[245]

- **AFD Sustainable Use of Natural Resources and Energy Finance (SUNREF) West Africa II**

The SUNREF West Africa II program aims at financing small and medium green investments in Ghana and Nigeria, with a view of creating a demonstrative effect on the market. The program provides both technical assistance (TA) and credit lines to local financial institutions to finance small and medium sized renewable energy and energy efficiency projects. The program is a funded by the AFD and co-financed by the EU-Africa Infrastructure Trust Fund (ITF), with a total budget of EUR 156 million for both countries. AFD, in collaboration with the Energy Commission Ghana, is preparing to launch the TA component of the program to support local banks and stakeholders in Ghana towards the development of energy efficiency and renewable energy projects. The TA program is expected to run for 36 months with a possibility of extension. A solicitation for expression of interest for qualified consulting firms to implement the program was conducted in October 2018.[246]

- **National Rooftop Solar Programme (NRSP)**

The NRSP is a capital subsidy scheme under which free solar panels up to a maximum capacity of 500Wp are provided to qualified beneficiaries. The primary objective of the program, which is being implemented by the Energy Commission, is to provide 200MW peak load relief on the national grid in the medium term through the installation of 200,000 rooftop solar PV systems. The program is targeted at the residential, public, commercial and industrial sectors, however, the first phase of the NRSP, which kicked off in February 2016 is targeted at installing 20,000 residential rooftop solar systems. The homeowners are required to pay 70% of the total system cost, which is between GHS 4,000-6,000 (USD 750-1,150), to cover the cost of balance of system components and installation costs. In order to enable beneficiaries, meet their

[244] As previously mentioned, however, Heritage Bank's license was withdrawn by the BoG in 2018 due to its inability to meet the new regulatory minimum capital requirement.
[245] "Market Assessment Report on Clean Energy: Ghana," USAID Climate Economic Analysis for Development, Investment and Resilience (CEADIR), (June 2018): https://www.climatelinks.org/resources/renewable-energy-lending-west-africa
[246] "Technical Assistance Facility to support local banks and stakeholders in Ghana towards the development of energy efficiency and renewable energy projects: Sustainable Use of Natural Resources and Energy Finance (SUNREF) Programme," AFD: https://afd.dgmarket.com/tender/24402279; and
"SUNREF West Africa II," AFD: https://ec.europa.eu/europeaid/blending/sunref-west-africa-ii-2_en

part of the obligation, the Energy Commission entered into partnership with a number of financial institutions to provide loans to applicants. As a result, a number of the local FIs in the country including UMB, UniBank (now defunct), and afb Ghana launched special solar facilities to enable customers who meet their requirements to benefit from the program. Nevertheless, to date, the NRSP has fallen well short of its targets. As of May 2017, the NRSP had received 2,664 applications from residential applicants and 2,289 in the Greater Accra Region were authorized to engage licensed solar vendors. Only 872 of these applicants received approvals for the subsidy and 443 completed installations.[247]

- **Rural Development Fund (RDF)**

The Rural Development Fund (RDF) is a USD 25 million fund initiated by the Danish Government to ease the liquidity and capital constraints on financial institutions in rural areas in Ghana by providing guarantees and term credit facilities to support lending to rural MSMEs, particularly those in the agriculture and renewable energy sectors (80/20% allocation, respectively). The RDF is a component of the Support to Private Sector Development Programme (SPSD) III of the Danish International Development Agency (DANIDA), which aims to promote inclusive and greener economic growth in Ghana through private sector development leading to increased income and better welfare of Ghanaians. The Fund, which is managed by the Danish Investment Fund for Developing Countries (IFU) until mid-2024, will be channeled through on-lending agreements with local banks. The fund is expected to lend to the banks at a rate indexed to the prevailing Ghana Treasury Bill yield, with local banks lending to clients at a rate equal to the RDF's as the base plus a margin not exceeding 10%. Selection of the FIs that will participate has not taken place yet. [248]

3.2.4.2 Key Barriers to Off-Grid Solar Lending

- **Unfamiliarity with the Off-Grid Solar Sector**

One of the barriers to off-grid solar lending in Ghana is the fact that the local FIs largely have a limited understanding of the sector. Most local FIs lack expertise in assessing risks associated with off-grid solar lending and structuring/developing customized off-grid solar products. While donor programs such as CEADIR have provided some level of training to some of the local lending institutions in the country, there remains a significant gap to be filled. All of the interviewed FIs stressed the need for technical assistance.

- **High Interest Rates and Short Tenor of Loans**

Access to affordable financing remains a major challenge for local companies, including off-grid solar companies, as commercial bank interest rates get as high as 33%. Microfinance institutions on the other hand typically charge customers as much as 70% interest rate.[249] In addition, SME loans financed out of the normal business portfolio of commercial banks have shorter terms. All of the interviewed FIs emphasized that in order to make OGS projects more attractive, access to alternative funding options with low interest rates and longer tenors for on-lending to providers and end users/SMEs was necessary.[250]

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[247] "The National Rooftop Solar Programme," National Rooftop Solar Programme, (April 2017): https://www.transparency-partnership.net/sites/default/files/u2612/1-the_national_rooftop_solar_programme_ghana_appiah_25.04.17.pdf; and "Rooftop solar programme faces financial crisis," Graphic Online, (June 2017): https://www.graphic.com.gh/news/general-news/rooftop-solar-programme-faces-financial-crisis.html

[248] "Market Assessment Report on Clean Energy: Ghana," USAID Climate Economic Analysis for Development, Investment and Resilience (CEADIR), (June 2018): https://www.climatelinks.org/resources/renewable-energy-lending-west-africa; and "Support to Private Sector Development Programme; phase III (SPSD III), Denmark in Ghana, Ministry of Foreign Affair of Denmark: http://ghana.um.dk/en/danida-en/support-to-private-sector-development/

[249] "Ghana ranks second among highest interest rates countries," Business Day, (25 April 2016): https://www.myjoyonline.com/business/2016/April-25th/ghana-ranks-second-among-highest-interest-rates-countries.php

[250] "Ghana Market Challenges," Expoert.gov, (December 3, 2018): https://www.export.gov/article?id=Ghana-Market-Challenges; and

- **Lack of Credit History/High Collateral Requirements**

The lack of credit history/track record and weak balance sheet of most local off-grid solar companies is another barrier to financing of the sector. These firms are also typically unable to meet the stringent collateral requirements of banks. All of the interviewed commercial banks indicated that credit guarantees would be necessary to encourage lending to the sector.

- **Foreign Exchange Risk**

Like other emerging economies, foreign exchange risk remains a major business risk. The vast majority of capital expenditure (equipment importation) for off-grid solar companies occur in foreign currency, usually in US dollars. However, the Ghanaian cedi has continued to decline in value relative to the US dollar in recent years, depreciating by 8.8% and 4.5% to the US dollar in 2018 and 2017, respectively. The Ghanaian cedi floating regime amid high current account deficit and low FX reserves make the currency vulnerable to external shocks as the US dollar strengthens. The volatility of the Ghanaian cedi remains a major problem for the cash flow of off-grid solar companies, making it difficult to attract working capital. Furthermore, there are limited options to hedge this FX risk and many stakeholders consider them expensive.[251]

- **Lack of Consumer Awareness/Poor Perception**

The project-based nature of awareness raising to date has meant that efforts have been focused in certain regions rather than extending nationwide; hence, public understanding of OGS is not uniform across the country. Moreover, some of the consumers who are familiar with OGS solutions have a poor perception due to the low quality of systems distributed under past programs. For instance, the GEDAP program in northern Ghana has led to the disbursement of subsidized low-quality products. As a consequence, commercial banks that participated in the NRSP found little demand for their solar loan products, largely due to customer perceptions of the quality and value of solar equipment relative to its cost.[252]

"Ghana Access to Finance Note," World Bank, (October 2016): http://documents.worldbank.org/curated/en/956691533058661581/pdf/129096-WP-P151845-Ghana-A2F-Note-PUBLIC.pdf

[251] Entsie, B., "Research shows the Ghanaian currency recorded a depreciation of 8.8 percent in 2018," Business Insider, (January 2019): https://www.pulse.com.gh/bi/finance/research-shows-the-ghanaian-currency-recorded-a-depreciation-of-88-per-cent-in-2018/dptqb40; and
"Solar for Businesses in Sub-Saharan Africa," Responsability / Global Climate Partnership Fund, (January 24, 2019): https://www.responsability.com/en/media/3174/download?delta=0

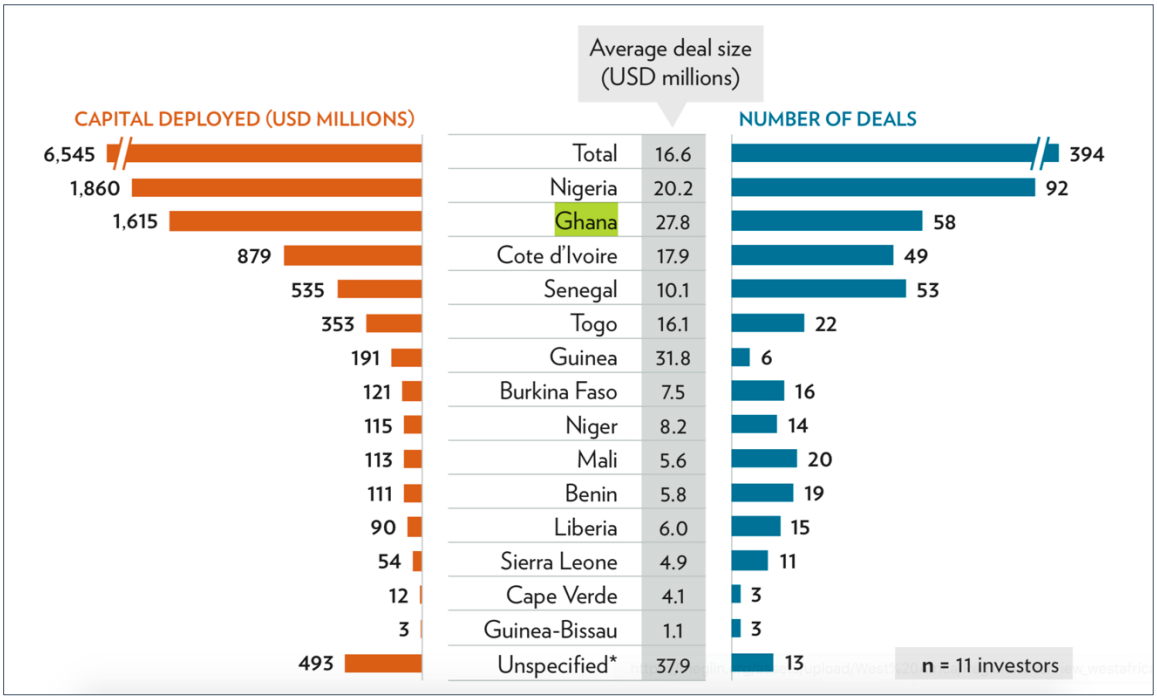
[252] "Accelerating access to electricity in Africa with off-grid solar: Ghana off-grid solar country briefing," DFID, ODI, GOGLA, SolarAid and Practical Action, (January 2016): https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/10248.pdf

3.3 Financial Institutions[253]

3.3.1 Development Finance Institutions

Between 2005 and 2015, USD 1.6 billion of capital was deployed across 58 direct investments in Ghana, with an average deal size of USD 27.8 million. The amount of funding the country received was the second most in the region, behind only Nigeria, and was equal to 24% of the region's total over the period (**Figure 59**).[254]

Figure 59: DFI Investment in West African Countries, 2005-2015



Source: Global Impact Investing Network and Dahlberg

As of 2015, there were eight active DFIs identified in Ghana, including AfDB, FMO, KfW/DEG, and IFC among others. The DFIs channeled most of their capital through large deals of more than USD 50 million which account for 70% of total capital deployed. However, in terms of number of deals, smaller deal sizes accounted for a sizable amount – 21 deals (36%) were less than USD 5 million. The DFIs targeted large enterprises and projects, mainly using debt and debt guarantees. In terms of sector focus, DFIs invested most heavily in energy, manufacturing, and ICT.[255] In addition to the abovementioned AFD SUNREF II financing program, the DFIs that have been active in supporting the off-grid solar sector in Ghana are described below.

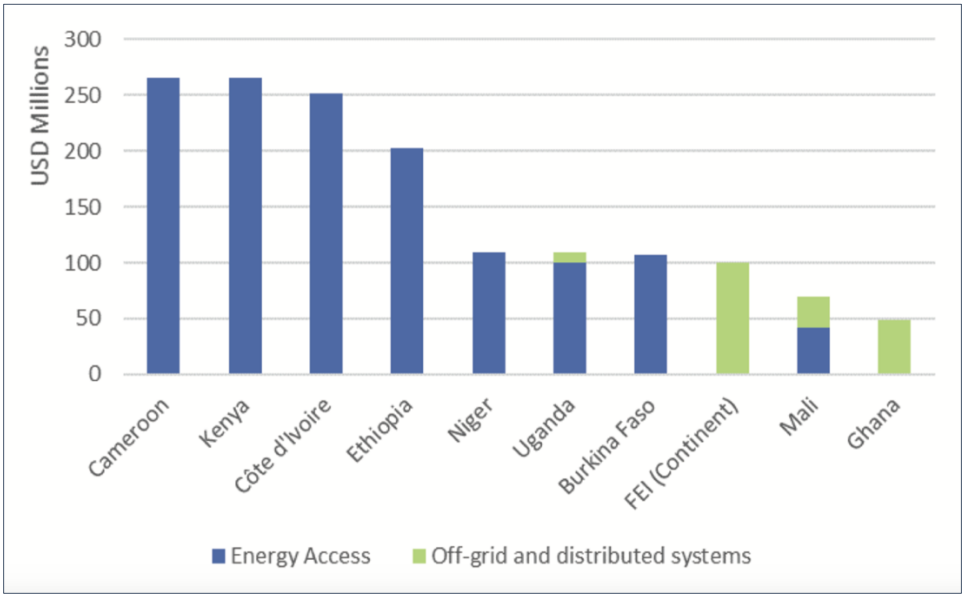
[253] Excluding commercial banks, which are reviewed in detail in **Section 3.2**.
[254] "The Landscape for Impact Investing in West Africa: Understanding the Current Status, Trends, Opportunities and Challenges," Global Impact Investing Network and Dahlberg, (2015): https://thegiin.org/assets/upload/West%20Africa/RegionalOverview_westafrica.pdf
[255] "The landscape for impact investing in West Africa," GIIN, Dalberg, The Impact Programme, (December 2015): https://thegiin.org/assets/upload/West%20Africa/Ghana_westafrica.pdf

- **African Development Bank Sustainable Energy Fund for Africa / Facility for Energy Inclusion**

The **Sustainable Energy Fund for Africa (SEFA)** is a USD 60 million multi-donor trust fund administered by the African Development Bank with the objective of supporting sustainable private sector led economic growth in African countries through the efficient utilization of clean energy resources and support small- and medium-scale renewable energy project development.[256]

The **Facility for Energy Inclusion (FEI)** is a USD 500 million Pan-African debt facility created by the AfDB to support the achievement of its access to energy goals by providing debt capital to SHS companies, small independent power producers and mini-grid developers. The launch of the FEI in 2016 led to a significant increase in AfDB financing for distributed renewable energy throughout Sub-Saharan Africa. Ghana received approximately USD 50 million in energy access financing from AfDB between 2014 and 2017 (**Figure 60**).

Figure 60: Distribution of AfDB Energy Access Financing in Sub-Saharan Africa, 2014-2017[257]



Source: Oil Change International and Friends of the Earth U.S.

The FEI Off-Grid Energy Access Fund (OGEF), structured by Lion's Head in partnership with the Nordic Development Fund, supports transaction structuring, provides local currency options to reduce risk for borrowers and their customers, and also offers technical assistance to companies to support off-grid market development.[258] The FEI OGEF, which launched in 2018, will initially focus on East Africa, Côte d'Ivoire, Ghana and Nigeria.[259]

[256] "Sustainable Energy Fund for Africa," African Development Bank, (2018): https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/

[257] Lee, A. Doukas, A. and DeAngelis, K., "The African Development Bank and Energy Access Finance in Sub-Saharan Africa: Trends and Insights from Recent Data," Oil Change International and Friends of the Earth U.S., (November 2018): http://priceofoil.org/content/uploads/2018/11/AfDB-Energy-Access-Finance-report-high-quality.pdf

[258] Facility for Energy Inclusion – Off-Grid Energy Access Fund: https://www.ogefafrica.com

[259] "African Development Bank, Nordic Development Fund and Partners launch Off-Grid Energy Access Fund with US$ 58 million," African Development Bank Group, (August 27, 2018): https://www.afdb.org/en/news-and-events/african-development-bank-nordic-development-fund-and-partners-launch-off-grid-energy-access-fund-with-us-58-million-18432/

- **DEG**

In 2015, German DFI, DEG, provided EUR 160,273 to the Ghanaian subsidiary of German start-up company, Solarkiosk AG, through its "Climate Partnerships with the Private Sector" program. Solarkiosk AG has pioneered a solar-powered energy and business outlet - Solarkiosk E-HUBB, along with an inclusive business model to deliver energy access to underserved remote off-grid areas and communities. The Solarkiosk E-HUBB is a solar technology solution, ranging from 1 to 4 kWp, which provides reliable 24/7 energy supply by incorporating smart metering that allows for energy usage, monitoring and efficiency optimization, including the energy stored in its secured battery pack for nighttime operation and power back-up. The DEG support was targeted at the implementation of a project aimed at establishing local manufacturing capacity for the production and assembly of Solarkiosk E-HUBBs in Ghana, in order to increase local value creation, drive down production costs and thus build the foundation for the scaling up of E-HUBBs in the West African market. Subsequently, in September 2016, Solarkiosk announced the inauguration of its first locally manufactured E-HUBB in Accra, Ghana.[260]

3.3.2 Specialized Deposit-taking Financial Institutions

There are many different types of specialized financial institutions playing a key role in financial inclusion in Ghana, serving a wide range of market niches, from rural smallholders to traders to urban small enterprises. These include rural and community banks (RCBs), savings and loans companies (S&Ls), credit unions (CUs), microfinance institutions (MFIs), financial non-governmental organizations (FNGOs) and mobile savings collectors (known as susu collections). These institutions are collectively known as Specialized Deposit-taking Financial Institutions (SDIs). The current SDI legal framework is sub-divided into tiers (**Table 58**). Licensing, registration, capital requirements etc. are tailored to the different capacities, sizes, and levels of risk across the tiers.

Table 58: Specialized Deposit Institutions Regulatory Framework[261]

Tier	Type of Institution	Minimum Paid-Up Capital Requirement
Tier 1	Rural and Community Banks (RCBs)	GHS 1 million
	Finance Houses and Savings and Loan Companies (S&Ls)	GHS 15 million
Tier 2	Microfinance Companies (MFCs)	GHS 2 million
	Credit Unions (CUs)	N/A
Tier 3	Financial Non-Governmental Organizations (FNGOs)	GHS 300,000
	Money Lending Companies	GHS 2,000,000
Tier 4	Susu Collectors and Individual Money Lenders	N/A

Source: Bank of Ghana

Together, SDIs account for about 14% of bank and SDI assets. As shown in **Figure 61**, S&Ls and Financial Houses are relatively large and focus on consumer lending while RCBs and credit unions – both owned and governed by local communities – tend to have broader outreach, offering savings, credit, and payment services to less included groups such as women, the poor, and rural residents.[262]

[260] "SOLARKIOSK – The Energy Gateway to the Base of the Pyramid," KfW International Climate Initiative: https://www.international-climate-initiative.com/fileadmin/Dokumente/landingpages/sairec2015/150918_5_Solarkioskweb.pdf; and https://www.solarkiosk.eu/2016/09/made-in-ghana-e-hubb/

[261] Bank of Ghana: https://www.bog.gov.gh/privatecontent/Banking_Supervision/LICENSING%20REQUIREMENTS%20FOR%20SAVINGS%20AND%20LOANS%20AND%20FINANCE%20HOUSES.pdf

[262] "Ghana Financial Sector Development Project," Project Appraisal Document, World Bank Report No. PAD 2862, (August 29, 2018): http://documents.worldbank.org/curated/en/768071536096255699/pdf/Revised-PAD-P161787-002-08312018.pdf

Figure 61: Specialized Deposit-taking Financial Institutions Financial Indicators

	# Institutions	Assets (GH¢)	Deposits (GH¢)	# Deposit Accounts	# Active Institutions
Microfinance Institutions (MFIs)	565	1,762,692,789	1,035,557,600		359
Microfinance Companies (MFCs)	484	1,526,463,875	1,022,894,336	1531715**	306
Micro Credit Companies (MCCs)	69	212,656,789	8,903,214	1099**	43
Financial NGOs (FNGOs)	12	23,572,126	3,760,050	-	10
Rural and Community Banks (RCBs)	141	3,856,324,832	3,061,877,771	7278697*	110
Susu Collectors	576				
Credit Unions*	522	1,084,012,265	5,584,325		-
Savings and Loans Companies (S&Ls)	37	6,548,633,813	4,060,704,247		36
Finance Houses	23	3,172,371,153	2,021,241,054		20

*As of December 2017; **As of June 2017

Source: BoG, Association of Rural Banks (ARB) Apex Bank, and Ghana Cooperative Credit Unions Association (CUA).

Source: Bank of Ghana

However, these SDIs have remained vulnerable to instability and plagued with inefficiency as oversight is much weaker than for the money deposit banks, particularly given the large number of institutions and the limited staff capacity of the regulators.[263] In September 2017, the IMF reported that many Ghanaian MFIs fall below minimum regulatory paid-up capital levels and in early 2018, customers of four of these institutions were reportedly unable to access their funds.[264]

Tier 1 Institutions

- **Rural and Community Banks (RCBs)**

As of December 2017, there were 141 licensed RCBs in Ghana. **Table 59** shows that deposits remained the prime funding source for the RCBs while investments remain the dominant asset item, accounting for 38.8% of the total assets.[265] As part of the banking sector consolidation exercise, the BoG has raised the minimum paid-up capital requirement for RCBs to GHS 1 million (USD 190,000) with the deadline for compliance set for end-December 2018. As of October 2018, a total of 47 RCBs were yet to meet the requirement. [266]

[263] Banking in Africa: Delivering on Financial Inclusion, Supporting Financial Stability, European Investment Bank, October 2018.
[264] Ibid.
[265] BOG 2017 Annual Report
[266] "47 rural banks yet to meet capital requirement," GH Headlines, (October 2018): http://www.ghheadlines.com/agency/ghana-web-/20181007/91718667/47-rural-banks-yet-to-meet-capital-requirement

Table 59: Assets and Liabilities of RCBs in Ghana (GHS million)

Indicator	2016	2017
Total Assets	3,053	3,644
Cash and Bank Balances	414	452
Investments	1,150	1,414
Loans & Advances	989	1,161
Other Assets and PPE	500	616
Liabilities and Shareholders' Fund	3,053	3,644
Liabilities	2,647	3,166
Deposits	2,382	2,880
Borrowings and other Liabilities	265	285
Shareholders' Funds	406	478
Paid-Up Capital	126	169
Reserves	280	309

Source: Bank of Ghana

- **Non-Bank Financial Institutions (NBFIs)**

The non-bank financial institutions sub-sector of the Ghanaian banking industry is made up of savings and loans companies (S&L), finance houses (FH), and mortgage finance and leasing companies. As of December 2017, the asset size of the sub-sector formed 11.0% of the entire banking sector's assets. As shown in **Table 60**, the major source of funding for the NBFIs was deposits from the S&L group, which accounted for 57.2% of total assets at end-December 2017.

Table 60: Assets and Liabilities of NBFIs in Ghana (GHS million)

Indicator	2016	2017
TOTAL ASSETS	9,560.5	12,146.8
Cash and Bank Balances	1,094.1	1,406.1
Investments	2,650.5	3,343.3
Loans & Advances	4,337.3	5,321.7
Other Assets and PPE	1,478.7	2,075.7
LIABILITIES AND SHAREHOLDERS' FUND	9,560.5	12,146.8
Liabilities	8,434.1	10,712.3
Deposits	5,758.5	6,943.6
Borrowings and other Liabilities	2,675.6	3,768.8
Shareholders' Funds	1,126.4	1,434.5
Paid-Up Capital	997.8	1,233.5
Reserves	128.6	201

Source: Bank of Ghana

Tier 2 and Tier 3 Institutions

➢ Microfinance Institutions

As of 2017, there were 566 licensed microfinance institutions (MFIs) in Ghana, including 484 microfinance companies (MFCs), 70 money lending companies and 12 financial NGOs. In 2017, the BoG suspended the granting of new licenses to MFIs and the MFIs were required to meet a minimum paid-up capital of GHS 2 million (USD 380,000) by end-June 2018. As of end-December 2017, 35 MFIs had met the requirement. Deposits have remained the dominant source of funding for the MFIs as shown in **Table 61**. In 2017, the total assets of deposit-taking MFIs were GHS 1.1 billion (USD 210 million), while the total assets attributable to non-deposit taking MFIs was GHS 170 million (USD 32.4 million).[267]

Table 61: Assets and Liabilities of MFIs in Ghana (GHS million)

Indicator	2016	2017
TOTAL ASSETS	1,272	1,286.5
Cash and Bank Balances	294.6	382.6
Investments	48	33.5
Loans & Advances	535.9	554.1
Other Assets and PPE	393.4	316.3
LIABILITIES AND SHAREHOLDERS FUNDS	1,272	1,286.5
Liabilities	1,002.4	1,098.5
Deposits	686	741.4
Borrowings and other Liabilities	315.4	357.1
Shareholders' Funds	269.6	188
Paid-Up Capital	328	288.6
Reserves	-58.3	-100.6

Source: Bank of Ghana

➢ Credit Unions

Ghana has an active and expanding credit union sector. As of 2017, there were 522 credit unions with combined GHS 866 million in assets, GHS 713 million in member savings and shares, and 810,104 members (44% women, 49% male, and 7% groups).[268] According to the Non-Bank Financial Institutions Act, 2008 credit unions in Ghana are required to be registered and licensed by the BoG. Licensing requirements and operating guidelines for Credit Unions issued by the BoG in 2017 stipulate that each CU must have a minimum membership of 150 and maximum of 600. Also, no single deposit shall exceed 10% of the total deposit of the credit union without written approval of the BoG while loans granted to a member cannot exceed 10% of the assets of the credit union. In addition, the credit unions must maintain a minimum Capital Adequacy Ratio of 15% and a Secondary Reserve Ratio of 18%. Credit Unions are required to maintain a statutory reserve fund into which at least 25% of annual profits are to be paid.

Furthermore, in 2015, the Credit Union Legislative Instrument (LI 2225) was passed, giving the Ghana Cooperative Credit Unions Association (CUA), the umbrella body of all Credit Unions in Ghana, the powers to supervise all credit unions in the country on behalf of BoG. The LI 2225 also established the Co-

[267] Bank of Ghana 2017 Annual Report
[268] Only credit unions affiliated to CUA

operative Credit Unions Supervisory Agency[269] to oversee CUA and take all relevant decisions, including issuance of policies and guidelines, monitoring of the financial condition of credit unions, etc. However, the sector remains faced with several challenges including limited data submission by credit unions to CUA (only 120 credit unions submit monthly financial reports regularly and around 270 credit unions do not report at all); limited technical capacity (skills, manuals, processes, and procedures); lack of a reliable offsite surveillance application that could allow credit unions to submit prudential returns electronically; and outdated Management Information Systems (MIS) which hampers the efficiency of credit unions' operations. Currently, 254 credit unions manage their operations manually, making submission of data to CUA difficult and the onsite examinations by CUA lengthy. In a bid to address these issues, the World Bank is planning to launch a project aimed at building the capacity of CUA's Supervision Division to ensure that it effectively delivers on in its mandate of supervising credit unions, contributing to their soundness.[270]

Tier 4 Institutions

- **Susu Collectors and Individual Money Lenders**

Following a review of the Non-Bank Financial Institution Act in Ghana, activities undertaken by individual susu collectors, susu enterprises, and individual money lenders are now classified as Tier 4 activity. The Act stipulates that all Tier 4 operators shall belong to an umbrella association such as the Ghana Cooperative Susu Collectors Association (GCSCA). Subsequently, the BoG mandated GCSCA to assume the function of registering and supervising the activities of the Susu Collectors in the country. A 2016 study conducted by the GCSCA with funding from the Business Sector Advocacy Challenge Fund (BUSAC) found that only 472 (31%) of the 1,500 susu collectors operating in the country, with a client base of over 2 million, are formally licensed under the self-regulation scheme. The remaining 69% continue to operate without license and unchecked as GCSCA does not have the mandate to sanction non-complaint operators.[271]

3.3.3 Informal Financial Institutions

Much like in other African states, there is a large informal financial sector in Ghana (**Figure 62**). This sector often serves as a major source of savings and credit services for women, the low-income population and others who lack access to formal institutions. According to the Financial Inclusion Insights (FII) survey in 2015, 29% of adult Ghanaians still used informal financial services and products that are not regulated by the Government.

Village Savings and Loan Associations (VSLAs) are the most common type of these informal institutions. These VSLAs, which are present in both urban and rural areas, are typically groups of around 30 members and often take the form of rotating savings and credit associations, in which members make deposits into a group fund and take turns borrowing funds for investment purposes or household needs. The VSLAs hold regular meetings which allow members to hold each other responsible for saving, repaying loans, and keeping funds safe. According to Savings Groups' Information Exchange, there are 10,832 savings groups in the country, comprised of 282,001 members (an average of 26 members per group).[272] Of these members, women are the largest participants, comprising 76.4% or approximately 214,320 members. These groups

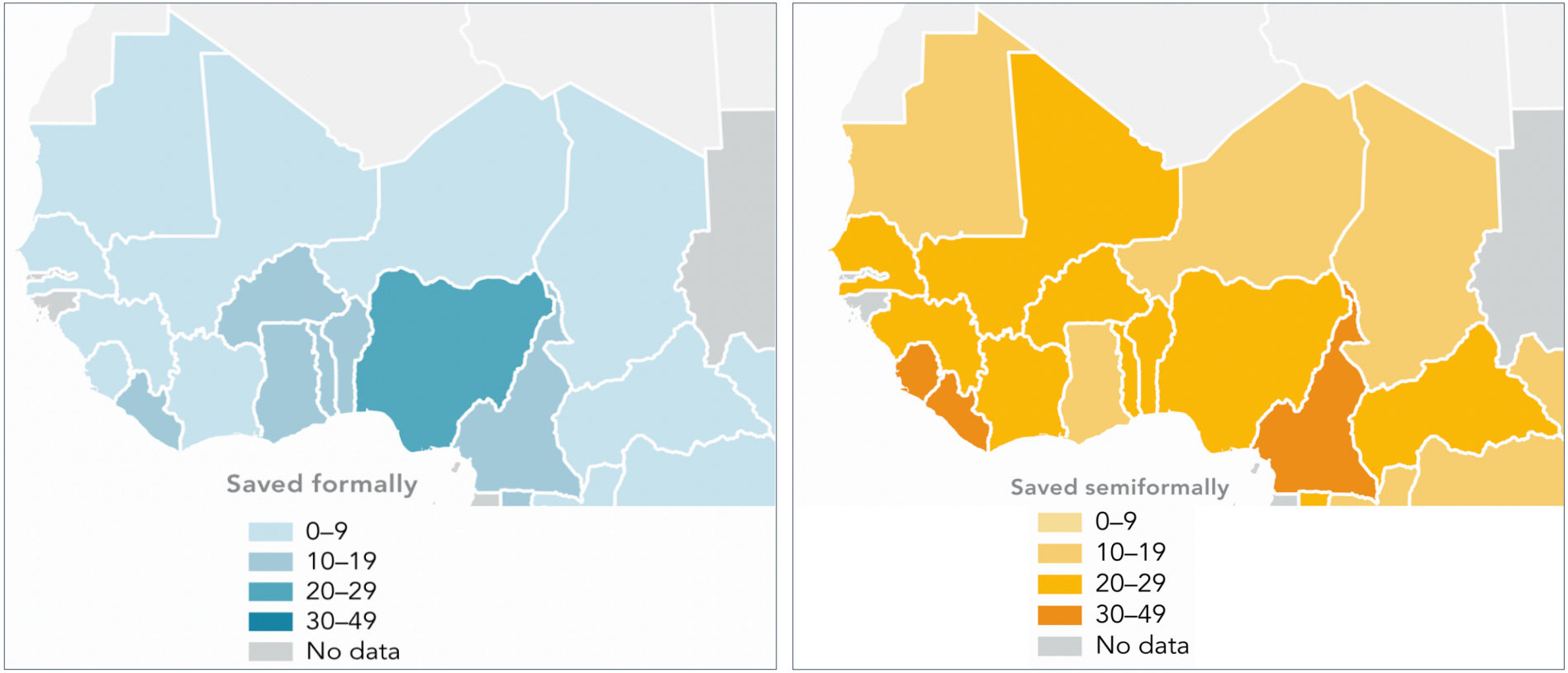
[269]The Agency comprises an executive chairperson nominated by BoG, two representatives from BoG, and one representative from eac h ofthe following institutions: Ministry of Finance, CUA, Department of Co-operatives, and GHAMFIN.
[270] http://documents.worldbank.org/curated/en/768071536096255699/pdf/Revised-PAD-P161787-002-08312018.pdf
[271] "About 70% of 'Susu' collectors operating illegally," GhanaWeb, (February 2016): https://www.ghanaweb.com/GhanaHomePage/business/About-70-of-Susu-collectors-operating-illegally-417794 and "69% of Susu collectors operate illegally: BUSAC Study," Ghana Co-operative, Susu Collectors Association, (June 2018): https://ghanasusu.com.gh/2018/06/12/69-of-susu-collectors-operate-illegally-busac-study/
[272] The data captures only 49 projects, mainly facilitated or implemented by CARE, Plan International, and World Vision. Therefore, the actual number and reach of savings groups in Ghana is much higher.

have approximately USD 13 million in savings and USD 8.7 million in outstanding loans while the dropout rate among members is 2.9%.

While the VSLAs and other informal financial institutions have been instrumental in offering financial services to the rural, poor and excluded segments of the population, there remain some challenges including inadequate record keeping, financial planning and internal governance challenges which limit opportunities to establish partnerships with formal financial services providers. To address this, the UNCDF's Microlead project worked with Fidelity Bank, GN Bank, and Sinapi Savings and Loans between 2014 to 2017 to help link informal savings groups to formal financial institutions, ultimately reaching 60,000 beneficiaries. In addition to this, the World Bank is also planning a project to promote private sector-led initiatives to link VSLAs to formal financial services providers with a major focus on the least financially included regions of the country, women, and the poor in order to increase formal financial inclusion in the country. [273]

[273] "Ghana Financial Sector Development Project," Project Appraisal Document, World Bank Report No. PAD 2862, (August 29, 2018): http://documents.worldbank.org/curated/en/768071536096255699/pdf/Revised-PAD-P161787-002-08312018.pdf

Figure 62: Share of Adults Saving in the Past Year (%), 2017[274]



NOTE: Maps exclude Cabo Verde (no data)

Source: World Bank Global Findex Database

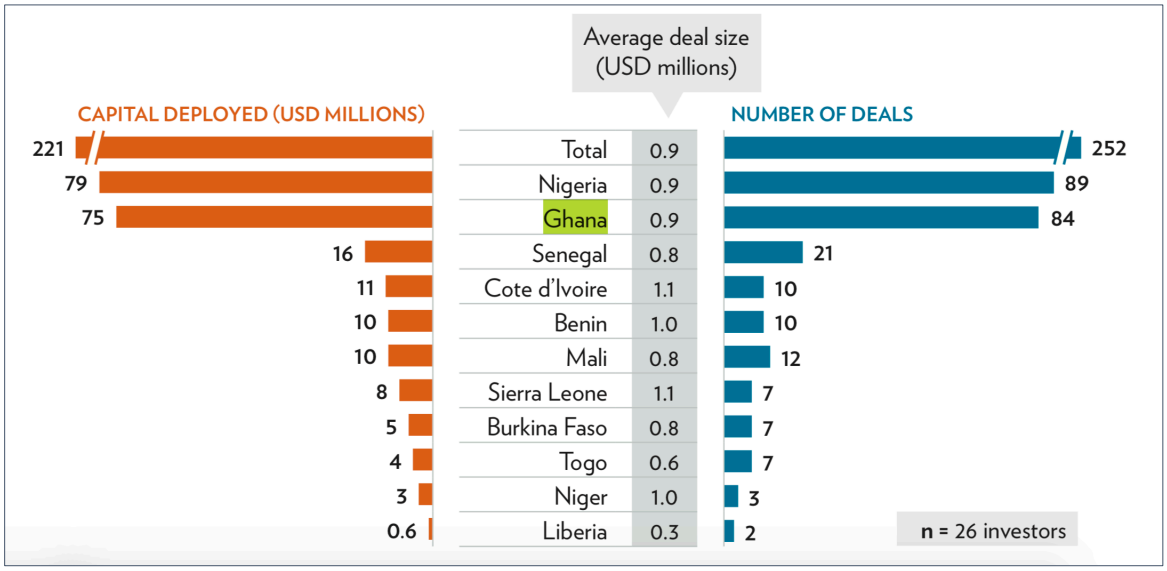
Figure 62 shows how the savings behavior of adults varies in West Africa and the Sahel. The shade of the country corresponds to the magnitude of the indicator; the darker the shade, the higher the value. Saving semi-formally is much more common than saving formally across the region, including in Ghana.

[274] Demirguc-Kunt et al., 2017.

3.3.4 Impact Investors

An assessment carried out by the Global Impact Investing Network (GIIN) found that while impact investing steadily increased across Africa between 2005-2015, most of the investment in West Africa has been highly concentrated. During this period, Ghana was the second largest recipient of impact capital deployed in the region, behind Nigeria, with a total of USD 75 million deployed across 84 deals (**Figure 63**).[275]

Figure 63: Non-DFI Investment in West African Countries, 2005-2015



Source: Global Impact Investing Network and Dahlberg

According to the GIIN, there were 25 impact investors active in the country in 2015. These include AgDevCo, Injaro Investments, JCS Investments and Lundin Foundation. Impact investors have invested mostly in financial services, housing, and agriculture. Most of the capital deployed was in the USD 1–5 million range and 75% of the deals were below USD 1 million. The impact investors balance their portfolios evenly with debt and equity investments in SMEs in the startup and growth stages and invest for approximately five to seven years in each deal before exiting. Expected returns of 18-25% internal rate of return (IRR) were typically required for the equity investments. This is quite high and is attributable to the high interest rates prevailing in the country. Furthermore, most impact investors are headquartered outside of Ghana, with five having a local presence as of 2015. These investors rely almost exclusively on foreign sources of capital to fund their activities. JCS Investments was the only identified impact investor that was founded in the country.[276] A discussion on the impact investors that have been active in the off-grid solar space in Ghana thus far is presented below.

- **Acumen**

Acumen is a non-profit impact investment fund incorporated in 2001 with seed capital from the Rockefeller Foundation and Cisco Systems Foundation. Acumen raises charitable donations to make equity investments

[275] "The Landscape for Impact Investing in West Africa: Understanding the Current Status, Trends, Opportunities, And Challenges," Global Impact Investing Network and Dahlberg, (2015): https://thegiin.org/assets/upload/West%20Africa/RegionalOverview_westafrica.pdf

[276] Ibid.

in early-stage companies that provide a product or service to the poor. In 2017, Acumen invested in PEG Africa, a Ghana-based company providing SHS to off-grid households in West Africa on a PAYG basis. Acumen participated in PEG's USD 13.5 million Series B raise alongside Blue Haven Initiative, EAV, Investisseurs & Partenaires (via IPAE 1 fund), ENGIE Rassembleurs d'Energies and PCG Investments. The funding round also included a syndicated loan with participation from six lenders, including SunFunder, ResponsAbility, Oikocredit, Global Partnerships and Palladium Impact Investments. So far, PEG has sold more than 16,000 SHS in rural areas in Ghana and Côte d'Ivoire with plans to expand across West Africa.[277]

- **CAMCO**

Founded in 1989, CAMCO Clean Energy is a leader in renewable energy finance, providing developers with access to various financing products and services. Since its formation, the company has provided finance solutions to 180 projects globally worth USD 15 billion. CAMCO is currently managing the Renewable Energy Performance Platform (REPP), which was set up in 2015 to mobilize private sector development activity and investment in small to medium-sized renewable energy projects (typically up to 25MW) in sub-Saharan Africa, and is supported with GBP 148 million funding from the UK's Department for Business, Energy and Industrial Strategy (BEIS) and the International Climate Finance initiative.[278] CAMCO has three offices in Sub-Saharan Africa, one of which is located in Ghana, covering West Africa.

- **Oikocredit**

Oikocredit is a social impact investor and worldwide cooperative established in 1975. Oikocredit promotes sustainable development by providing loans, equity investments and capacity building particularly in low income countries in Africa, Asia and Latin America. Guided by the principle of empowering people to sustainably improve their livelihoods, Oikocredit finances organizations active in inclusive finance, agriculture and renewable energy. The cooperative is privately financed by individuals and institutions who want to use their money for positive change. As of 2017, Oikocredit and its financial partners had reached 36 million (84% female, 49% rural) clients and provided 15,600 households with improved access to energy. In 2016, Oikocredit made its first investment in renewable energy in West Africa by extending a USD 500,000 loan to PEG Africa, a PAYG solar provider active in Ghana, Côte d'Ivoire, and Senegal.[279]

- **FRAGG Investment Management**

FRAGG Investment Management is an impact investor and SME-focused fund that mobilizes investment and raises capital for high-growth companies in West Africa. FRAGG finances and invests in growing and inclusive SMEs that create social and environmental impact but are not able to attract capital for their business at affordable conditions. The fund provides businesses with long-term risk capital that allows them to operate at their full potential; these come by way of long-term debt facility and equity investments.[280] Outside of Ghana, the fund is also engaged in Benin, Togo, Nigeria and Côte d'Ivoire.

[277] "Providing affordable solar home systems to households in West Africa with 'Pay-As-You-Go' financing, PEG: https://acumen.org/investment/peg/ and
"PEG Africa completes US$13.5 million fundraise," Investisseurs & Partenaires, (June 2017): http://www.ietp.com/en/content/peg-africa-completes-us135-million-fundraise

[278] REPP is supporting a 20MW grid-connected solar PV project in Tilli, north-east Ghana in the form of a loan to pay for the feasibility study and other developmental costs.

[279] "Oikocredit supports expansion of home solar in West Africa with PEG Ghana," Oikocredit, (November 2016): https://www.oikocredit.coop/k/n2613/news/view/166003/9049/oikocredit-supports-expansion-of-home-solar-in-west-africa-with-peg-ghana.html

[280] FRAGG Investment Management: http://www.fragginvest.com/about-us/

3.3.5 Crowd Funders

- **Bettervest**

Bettervest is a German online crowdfunding debt platform for energy efficiency, renewable energy and CO_2 emission reduction projects. Bettervest can currently only lend to companies within Germany and Nigeria. Hence, Ghanaian firms are not able to raise funding directly on the platform. However, UMAWA Deutschland UG, a German limited liability company jointly owned by a German and a Ghanaian, has successfully financed six off-grid solar projects via the platform since 2016 as detailed below.

- UMAWA raised EUR 353,200 in 207 days from 660 investors for the installation of a 329.4 kWp solar system at Shop N Save Supermarket in Accra. The investors are to be repaid over a seven-year term with an expected return of 7%.[281]
- UMAWA raised EUR 244,950 in 122 days from 405 investors for the installation of a 115.44 kWp rooftop solar system at Alpha-Beta school in Accra. Investors are to be repaid over a period of 7 years with an expected return of 7%.[282]
- UMAWA raised EUR 126,400 in 68 days from 235 investors for the installation of a 61.36 kWp rooftop solar system at Jack and Jill School in Accra. Investors are to be repaid over a period of 7 years with an expected return of 7%.[283]
- UMAWA raised EUR 183,350 in 89 days from 272 investors for the installation of a 64.48 kWp rooftop solar system at Family Health Hospital in Accra. Investors are to be repaid over a term of 7 years with an expected return of 7%.[284]
- UMAWA raised EUR 108,150 in 14 days from 187 investors for the installation of a 40.96 kWp solar PV system at St. Martin de Porres School in Dansoman. Investors are to be repaid over a term of 7 years with an expected return of 7%.[285]
- In 2016, UMAWA raised EUR 100,050 in 34 days from 159 investors for the installation of a 42 kWp rooftop solar system at Maria Montessori School in Kumasi, Ghana. Investors are to be repaid over a term of 7 years with an expected return of 7%.[286]

- **Ecoligo**

Ecoligo is a Germany-based solar utility that provides a fully financed solar-as-a-service solution for businesses in emerging markets. Ecoligo finances solar projects through its digital crowd-investing platform[287] where it offers fixed and attractive returns to private investors with a minimum investment of EUR 500. In July 2018, Ecoligo financed three solar systems with a combined capacity of 40 kWp for Stanbic Bank Ghana in collaboration with local installers. The solar power systems were installed on the roofs of Stanbic Bank's Tema, Kasoa and Dansoman branches. The systems at Tema and Kasoa have capacities of 10 kWp each, while the system at Dansoman has a capacity of 20 kWp. EUR 50,000 was raised through Ecoligo's crowd-investing platform to finance the three systems. The campaign was backed by 42 private investors, who will receive 5.75% interest on their investments over a loan period of 12 years. Stanbic Bank Ghana leases the solar system from Ecoligo, making regular, fixed payments over a period.[288]

[281] "Photovoltaikanlage für einen Shop N Save Supermarkt in Accra/ Ghana – UMAWA," bettervest: https://www.bettervest.com/en/projekt/Photovoltaikanlage-SnS-Ghana-Umawa
[282] https://www.bettervest.com/en/projekt/Photovoltaikanlage-ABS-Ghana-Umawa
[283] https://www.bettervest.com/en/projekt/Photovoltaikanlage-JJS-Ghana-Umawa
[284] https://www.bettervest.com/en/projekt/Photovoltaikanlage-Krankenhaus-Ghana-Umawa
[285] https://www.bettervest.com/en/projekt/Photovoltaik-Hybrid-System-Umawa
[286] https://www.bettervest.com/en/projekt/pv-ghana-umawa-montessori
[287] Ecoligo investments: www.ecoligo.investments
[288] "Energy access from the bottom up: start-up and SME showcase, 2018," Alliance for Rural Electrification, (September 2018).

3.4 Summary of Findings

- **Opportunity for ROGEP Credit Lines**: Ghanaian banks lack access to funding with the interest rates and tenors required to make OGS projects attractive to end users and SMEs. Local currency cost of capital remains so high for FIs that pricing for typical loans remain as high as 33% for commercial banks and 70% for MFIs. Furthermore, loans are usually short-term, as customer deposits (mostly short-term) remain the largest source of funding for Ghanaian banks. This severely constrains OGS market growth. Yet, taking up hard currency-denominated credit lines presents challenges for local lenders in Ghana, who would have to bear the FX risk. When pricing in a hedge to cover this risk, most hard currency denominated credit lines become unattractive because the all-in cost of capital to the FI becomes too high to provide a competitive offer to borrowers. All of the interviewed FIs stressed the need to access alternative funding options with low interest rates and longer tenors for on-lending to providers and end users/SMEs, in order to make OGS projects attractive. Hard currency denominated lines of credit from ROGEP would need to be offered at deeply concessional pricing in the range of 3-6% with tenors of 3-7 years in order to be widely accepted by FIs operating in the market. Stakeholder interviews suggested that there is a potential for ROGEP to place as much as USD 80 million in credit lines if priced reasonably.

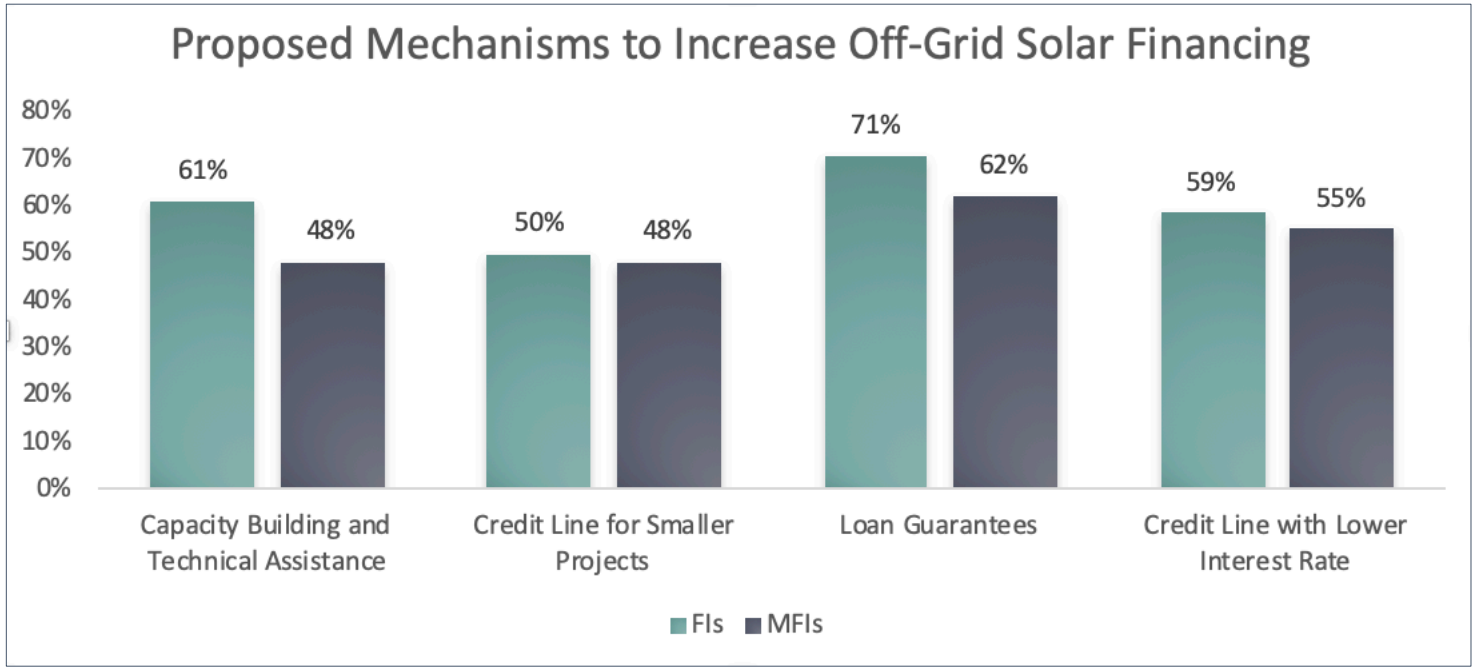
- **Collateral Requirements**: Commercial banks in Ghana have high collateral requirements of over 200% and are thus deeply constrained from originating OGS loans, as most local companies cannot meet these requirements. Therefore, the use of third-party *pari-passu* guarantees as an alternative form of collateral would enable banks to extend loans to borrowers without such high collateral requirements. Accordingly, all of the interviewed commercial banks emphasized the need for partial credit guarantees to encourage lending to the OGS sector (50% coverage is helpful; 70-80% coverage could be transformative). However, pricing from most available third-party guarantors can be in the range of 3%+ per annum, which some lenders view as too high to remain competitive. This creates an opportunity for ROGEP to either provide low-cost guarantees directly or to subsidize the premiums offered by existing third-party guarantors such as GuarantCo, Afrexim and Africa Guarantee Fund.

- **Risk Perception of New Lenders**: Although some commercial banks in Ghana (e.g. Stanbic Bank and UMB) have launched solar loan products and others are increasingly showing interest in the sector, most local FIs remain cautious of entering the market due to high perceived risk. In order to attract lenders to this market segment, there is a need for reasonably priced credit enhancement mechanisms. To cover these "market entry" risks for lenders that are unwilling to enter the market, guarantee instruments that cover first loss are needed. However, first-loss coverage does not address the key issue of collateral and is therefore likely insufficient on its own to stimulate growth in FI engagement unless it is coupled with third-party guarantee coverage.

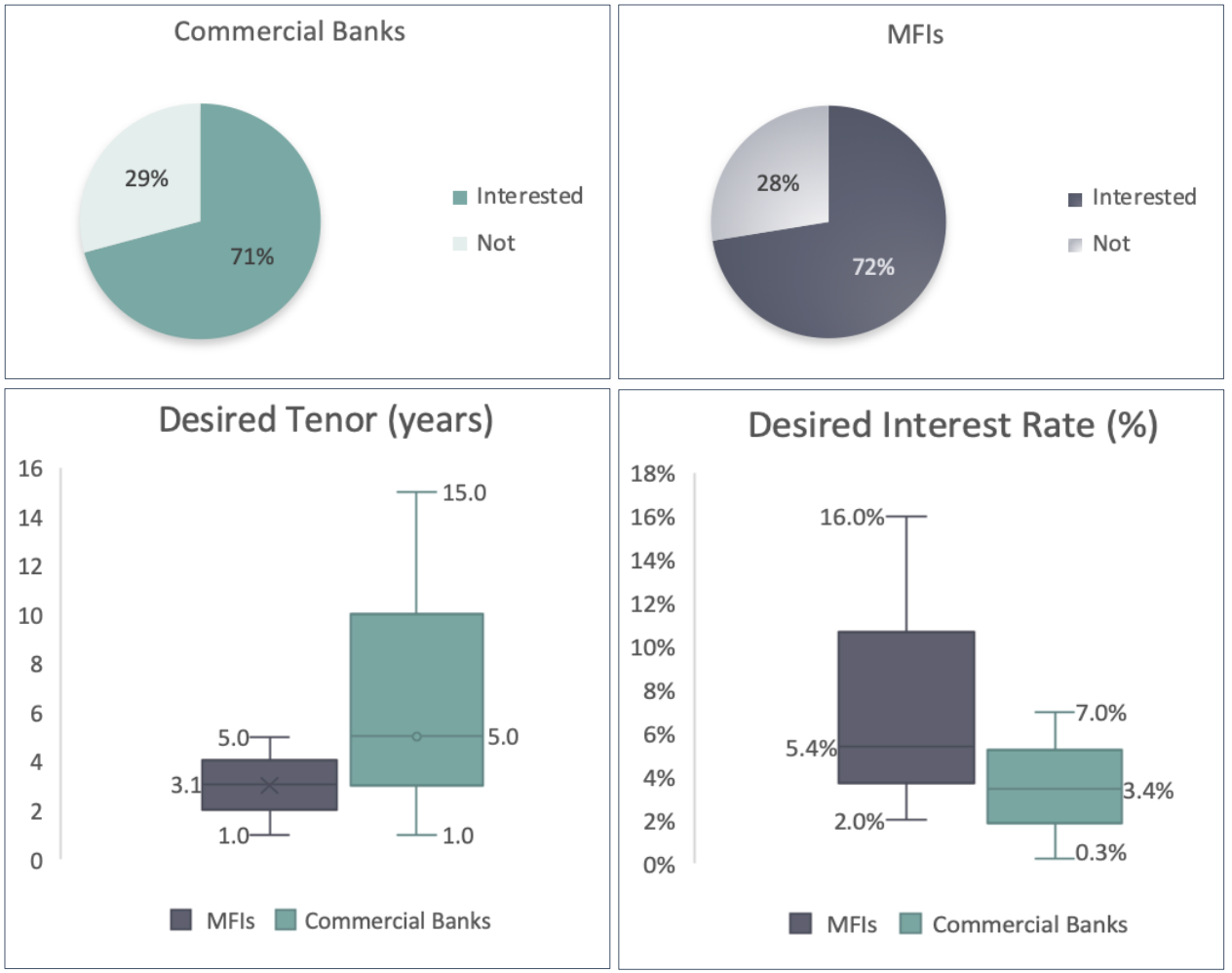
- **Technical Assistance**: A well designed TA intervention is just as important as reasonably priced credit lines and credit enhancements in accelerating OGS lending in the country. All of the interviewed FIs emphasized the need for TA in various forms. Recommended key areas of focus include training of bank credit department and account representative personnel to originate deals and appropriately assess the credit risk of standalone solar firms and projects, extensive due diligence support to qualify products and approve vendors; and support to new lenders to the space in product structuring and development as well as building deal flow. The TA intervention should build upon previous programs such as USAID CEADIR and be implemented in coordination with similar donor programs such as SUNREF to avoid duplication of efforts. Special attention should also be paid to offering advisory services on the side of the standalone solar enterprises. Lenders opine that these entrepreneurs often do not have proper financial management and accounting systems in place, are unable to present quality financial models and lack the expertise required to structure their companies to take on debt obligations.

- **Digital Financial Services**: The advent of digital financial services and mobile money is one of the most important developments in off-grid solar market development to date, as it has allowed new and innovative business models to emerge that are now driving unprecedented growth in the sector. Mobile communication technology facilitates payments for solar products and systems (lease-to-own, pay-as-you-go) and/or for electricity usage (energy-as-a-service) and enables monitoring for operations and maintenance of equipment. Expanding access to mobile money services also creates new opportunities to better serve women, the lower-income population, and other groups that are traditionally excluded from the formal financial system. The Government should take steps to support capacity building of and foster linkages between off-grid solar companies operating in the market and key stakeholders from various sectors, including energy access policymakers and regulators, financial and telecommunications companies, mobile network operators, financial service providers (commercial banks and microfinance institutions), mobile money service providers, international organizations, NGOs and civil society groups involved in financial inclusion etc.

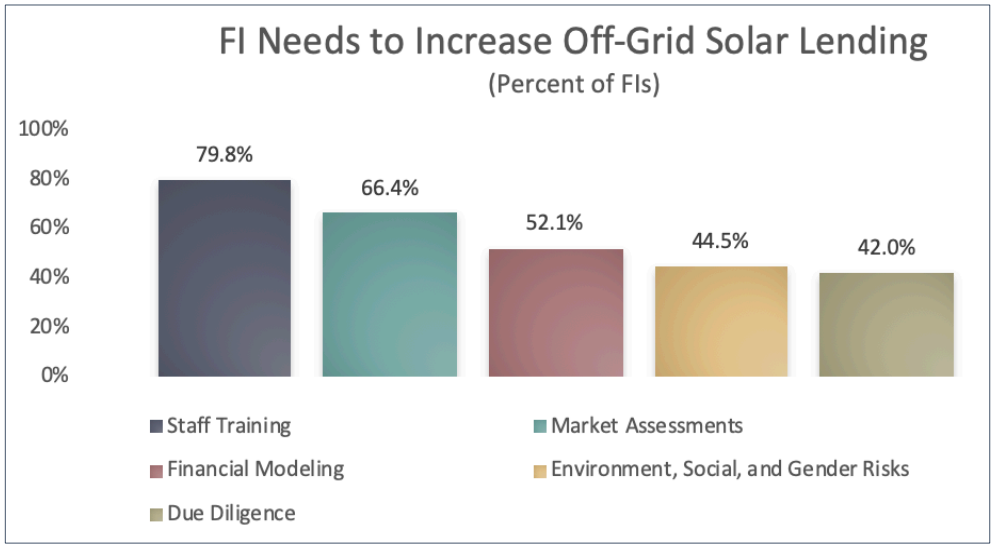
Key findings from the Task 3 FI survey activity are presented below. The results are based on feedback from a total of 121 FIs (including commercial banks, microfinance institutions and other non-bank FIs) that were interviewed across the 19 ROGEP countries. This summary only focuses on responses from commercial banks and MFIs, which together account for 92% of all respondents. See **Annex 3** for more details.



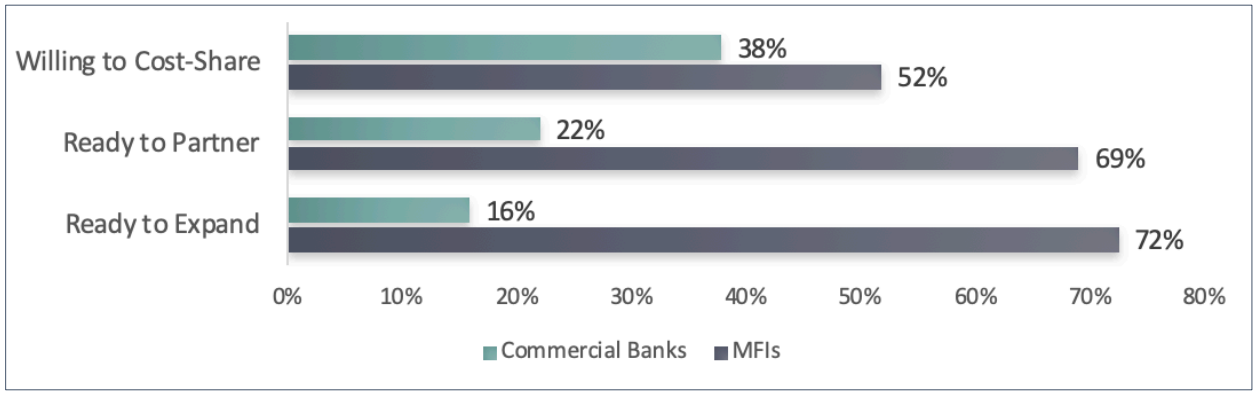
According to the survey, there is strong financial-sector interest across ROGEP countries to finance renewable energy projects, especially in off-grid solar. Commercial banks and MFIs identified loan guarantees as the most important measure that could improve their capacity to lend to the renewable energy sector. Most of the surveyed institutions also identified clear interest in credit lines.



More than 70% of surveyed commercial banks and MFIs are interested in a credit line to finance off-grid solar projects. Commercial banks want tenors of 1-15 years and interest rates from 0.25-7%. MFIs are seeking tenors of 1-5 years with interest rates from 2-16%. On average, commercial banks want a credit line with a 5-year tenor and 3.4 % interest rate, and MFIs want a 3.1-year tenor with 5.4% interest rate.



In addition to their clear interest in credit lines and loan guarantees to finance off-grid projects, surveyed financial institutions (commercial banks and MFIs) in ROGEP countries also identified several areas of internal capacity that require improvement in order to lend (or increase lending) to the off-grid solar sector.



Compared to commercial banks, MFIs reported a greater willingness to cost-share capacity building activities and a higher level of readiness to partner with solar companies and expand operations to serve rural and off-grid areas.

ANNEX 1: TASK 1 METHODOLOGY

STATE OF ENERGY ACCESS AND ENABLING MARKET ENVIRONMENT

Data presented in this section was collated from a range of sources either provided by ECREEE or obtained through supplemental market research (both desk research and interviews with key public officials and industry stakeholders) and then corroborated by attendees of national validation workshops in each country. Information obtained from the Task 2 focus group discussions and surveys of industry stakeholders (see **Annex 2**) was also used to support the Task 1 analysis.

GIS DATA ANALYSIS APPROACH / METHODOLOGY

1. Categorizations, key definitions and datasets for geospatial least-cost analysis

The main steps of the GIS analysis are as follows:
(i) Categorization/definition of settlements: scenario 2023;
(ii) Categorization/definition of settlements: scenario 2030;
(iii) Definition of un-electrified settlements within grid areas; and
(iv) Determination of population per settlement

1.1. Categorization/definition of settlements: Scenario 2023

1.1.1. *Electrification by grid extension* – settlements which are located within 5 km of the current electrical grid network[289] (according to WAPP densification plans).

1.1.2. *Electrification by mini-grid* – settlements that:
- Are located within 15 km of areas that have a high night-lights value (above 50/225 on grayscale raster)[290] and outside the buffer area established for the electrification by grid extension
- Are located within areas that have a population density of more than 350 people per km^2 (as defined by Eurostat for rural areas)[291], plus an additional 50 people per km^2 for greater feasibility of mini-grids[292] and are within 1 km[293] of a social facility (education center or health facility) and existing mini-grids of 2018.

1.1.3. *Electrification by off-grid stand-alone systems* – settlements that do not fall into the above categories

1.2. Categorization/definition of settlements: Scenario 2030

1.2.1. *Electrification by grid extension* – settlements which are located within 15 km of the current electrical grid network (average distance mentioned by energy utilities in West Africa)[294] or within 5 km of planned future line extensions[295]

[289] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)
[290] The 50/225 classification represents the areas emitting light of the country with reduction of scattering light. The classification was first introduced in the USAID report ZAMBIA ELECTRIFICATION GEOSPATIAL MODEL and evaluated in cross-checks throughout the country. USAID: https://pdf.usaid.gov/pdf_docs/PA00T2JC.pdf
[291] http://ec.europa.eu/eurostat/web/rural-development/methodology
[292] Identified in discussions with different international mini-grid developer.
[293] Preferred maximum distance for mini-grids from discussions with different international developer.
[294] Stakeholder interviews, 2018.
[295] NOTE: Low-voltage distribution lines were not considered in this analysis (data was unavailable)

1.2.2. *Electrification by mini-grid* – settlements that:
- Were defined as mini-grid settlements in scenario 2023
- Are located within 1 km of the above mini-grid settlements, which is the preferred distance of mini-grid developers for their grid according to discussions with several international developers.
- Are located within 15 km of economic growth centers – airports, mines and urban areas; average worker distance in Africa is 10 km, a distance of 5 km is added to include the growth of businesses in the periphery of the growth centers.[296]

1.2.3. *Electrification by off-grid stand-alone systems* – settlements that do not fall into the above categories

1.3. Definition of un-electrified settlements within grid areas

To identify settlements that are located close to the national electrical grid but are not served by it, the following criteria were used:

- Within the main grid line zones (see buffer zones for *electrification by grid extension* above)
- Outside 15 km night-lights of buffered areas to capture the densification within five years
- Within areas of low population density (less than 350 people per km^2)

1.4. Determination of population per settlement

A key component of the least-cost analysis was the number of people living in each settlement (city, town, village, hamlet) of a given country. While there are different publicly available sources of information on total population (e.g. World Bank demographic data), a more granular view of the population distribution was necessary to perform the geospatial analysis.

Another difficulty was the identification of locations of settlements. The exact location of each settlement (with given coordinates) was not available / accessible in many of the countries. As a result, the least-cost analysis had to revert to other studies of population distribution – such as the population distribution developed by WorldPop. WorldPop utilizes a range of geospatial datasets to develop accurate population data:

"New data sources and recent methodological advances made by the WorldPop program now provide high resolution, open and contemporary data on human population distributions, allowing accurate measurement of local population distributions, compositions, characteristics, growth and dynamics, across national and regional scales. Statistical assessments suggest that the resultant maps are consistently more accurate than existing population map products, as well as the simple gridding of census data." [297]

A Voronoi polygon analysis[298] was used to create boundaries for each identified settlement. These boundaries were then used in combination with the population density layer to estimate the total settlement population of the given year. The current annual national population growth rate of 2.2%[299] was applied to the geospatial analysis to project populations for the Scenario 2023 and 2030 analyses.

[296] Lall, Somik Vinay; Henderson, J. Vernon; Venables, Anthony J. 2017. Africa's Cities: Opening Doors to the World. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/25896 License: CC BY 3.0 IGO.
[297] https://www.worldpop.org
[298] To learn more about Voronoi polygons, see wikidot: http://djjr-courses.wikidot.com/soc128:qgis-voronoi-polygons
[299] The World Bank: https://data.worldbank.org/indicator/SP.POP.GROW?locations=GH

2. Summary of Key Datasets

The table below summarizes the key datasets used for 2023 and 2030 scenarios as well as the criteria applied and sources used.

Overview of Key Datasets of the Least-Cost Electrification Analysis								
Dataset	Description	Criteria used by technology						Source and Year
		Scenario 2023			Scenario 2030			
		On-grid	Mini-grid	Off-grid	On-grid	Mini-grid	Off-grid	
Electricity grid network (current)	Current national electricity grid network (HV & MV lines) [300]	≤ 5km distance	≥ 5km distance	≥ 5km distance	≤ 15km distance	≥ 15km distance	≥ 15km distance	GridCo, 2016[301], IAEA 2009[302] and ECOWREX, 2018[303]
Electricity grid network (planned)	Future network planned to be built (HV lines only) [304]	Not considered	Not considered	Not considered	≤ 5km distance	≥ 5km distance	≥ 5km distance	GridCo, 2016 and ECOWREX, 2018
Mini-grids	Existing clean energy mini-grids in 2018	Not considered	≤ 1km distance	≥ 1km distance	Not considered	≤ 1km distance from all identified mini-grids in Scenario 2023	≥ 1km distance from all identified mini-grids in Scenario 2023	ECOWREX, 2018
Night-lights	Night-time light emissions used to identify electrified areas	Not considered	≤ 15km distance	≥ 15km distance	Not considered	Not considered	Not considered	NASA Earth Observatory, 2016
Population density	Population distribution in people per km^2	≥ 350 people per km^2 [305]	≥ 350 people per km^2	≤ 350 people per km^2	Not considered	Not considered	Not considered	Hrsl layer Ciesin/ facebook lab, 2015

[300] Most recent distribution network lines from the three distribution companies, Electricity Company of Ghana (ECG), Northern Electricity Distribution Company (NEDCo) and En Clave Power could not be collected for this study.
[301] Grid map georeferenced by GIS analyst.
[302] The IAEA published a map of the electricity network in their Country Nuclear Power Profile (2014 Edition), Ghana update of 2009; Distribution lines of the regions Upper West, Upper East, Northern and Brong Ahafo were georeferenced and digitized by EVA. Source: https://www-pub.iaea.org/MTCD/publications/PDF/CNPP2014_CD/countryprofiles/Ghana/Ghana.htm
[303] http://www.ecowrex.org/mapView/index.php?lang=eng
[304] Planned distribution network lines from the three distribution companies, Electricity Company of Ghana (ECG), Northern Electricity Distribution Company (NEDC) and En Clave Power could not be collected for this study.
[305] Based on Eurostat definition plus an additional 50 people per km2 for greater feasibility of mini-grids as identified in discussions with different international mini-grid developer. Source: http://ec.europa.eu/eurostat/web/rural-development/methodology

Settlements	Settlement layer giving location of settlements across the country	Used	Used	Used	Used	Used	Used	Ghana Statistical Service, Census 2010
Social facility: education centers	Exhaustive list of Senior High Schools and Technical Institutions with few schools and kindergartens from OSM; Indicator of active local economy	Not considered	≤ 1km distance[306]	≥ 1km distance	Not considered	Not considered	Not considered	Ghana Education Service, Ministry of Education, 2018[307] and OSM, 2018[308]
Social facility: health centers	Indicator of active local economy	Not considered	≤ 1km distance[309]	≥ 1km distance	Not considered	Not considered	Not considered	Ghana Statistical Service, Census 2010 and HDX, 2018
Growth center: department capitals, airport, mines, urban areas	Economic growth centers for the analysis up to 2030 - defined for mini-grid areas; Urban areas as defined by Electricity Demand	Not used	Not used	Not used	Not considered	≤ 15km distance	≥ 15km distance	Department capitals: GeoNames, 2018 airports: OSM, 2017 mines: Humanitarian Data Exchange (HDX), 2017 urban areas: ECOWREX website, 2015[310]

[306] Preferred maximum distance for mini-grids from discussions with different international developer.
[307] http://www.ghanaschoolsinfo.org/explore
[308] OSM – OpenStreetMap
[309] Preferred maximum distance for mini-grids from discussions with different international developer.
[310] http://www.ecowrex.org/mapView/index.php?lang=eng

ANNEX 2: TASK 2 METHODOLOGY

Focus group participants included representatives from government, the donor community, NGOs, solar companies, business and industry associations, academia, community groups, and women's groups.

OFF-GRID SOLAR PV MARKET ASSESSMENT METHODOLOGY

Focus Group Discussions (FGDs) were held in Accra in June 2018 with key stakeholders from each of the four off-grid market segments analyzed under Task 2: (i) household, (ii) institutional, (iii) productive use, and (iv) supplier. Participants included a mix of public officials, representatives from the private sector, donor community, NGOs, business and industry associations, academia, community groups, and women's groups. Each market segment had its own dedicated meeting, although some stakeholders attended more than one discussion. Each FGD lasted approximately 90 minutes and covered a range of topics related to demand for off-grid solar vis-à-vis each market segment.

In addition to the FGDs, three additional survey activities were undertaken to support the Task 2 analysis: (i) a survey of large-scale international solar companies to gauge their level of interest in the country and wider region; (ii) a survey of local small-scale retail suppliers of solar equipment; and (iii) an assessment of an off-grid village to better understand how solar was being utilized for productive uses. The FGDs and surveys largely yielded qualitative inputs to supplement the quantitative analysis that was undertaken.

The methodology and assumptions utilized to assess each market segment under Task 2 is presented below.

1. HOUSEHOLD DEMAND

1.1 Household market segments

1.1.1 Total population without access to electricity was calculated using World Bank total population figures,[311] multiplied by electricity access rates from the International Energy Agency (IEA),[312] and translated to households using World Bank open data average household size. This method is used to align population data throughout the report, with IEA seen as an overarching source for energy access data and the World Bank providing important population and household income data. See **Annex 1** for more details.

1.1.2 Based on the country demographic and income data, the household solar market was broken down into segments by income quintile, as shown in **Section 2.1.1**. For the purpose of this analysis, income quintiles were aligned with energy tiers, as indicated by the Multi-Tier Energy Access Framework, which is roughly determined by household ability to pay for tier levels of energy. Quintiles were also aligned roughly with geographic segments.

1.1.3 World Bank demographic data used does not provide household income data broken down by rural, urban, on-grid or off-grid. For example, the data shows the total population falling under a certain poverty line, shows the total population that does not have access to electricity, and shows the total population that is rural, but does not cross reference any of these indicators to e.g. show the total rural population without access to electricity living under the poverty line. For this reason, assumptions were made regarding the number of households per income quintile that are off-grid (detailed in section 1.3.1 of these assumptions). It was assumed that

[311] World Bank Open Data, 2017: https://data.worldbank.org/

[312] IEA Energy Access Outlook, 2017: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf

the majority of off-grid households are rural. The data gap prevents the presentation of an overlapping map of the traditional poverty line income pyramid with electricity access.

1.2 Household energy expenditure and potential savings

1.2.1 Current household expenditure on energy-related items (believed to be candidates for replacement with solar products) was estimated using information from the Focus Group Discussions (FGDs).

1.2.2 From the existing household expenditures, "typical" monthly costs were estimated that households would incur in order to receive a standard level of electricity service according to the Multi-Tier Energy Access Framework.

1.2.3 The unit monthly costs were used for each of the energy-related items identified above.

1.2.4 The cumulative monthly expenditure was then determined for each tier.

1.2.5 Monthly expenditure by tier was compared with monthly cost associated with OGS products by tier to estimate potential household cost savings. Monthly cost for OGS products was based on representative data from the West African region.

1.2.6 In the process of this analysis, the following assumptions were made:

1.2.6.1 Solar system sizes and costs:

- Cost per watt on solar systems vary greatly and have changed rapidly in the past five years. Smaller pico and plug and play systems have a much higher per cost per watt. The USD/Watt prices are based on sample cost ranges from Lighting Global equipment available on the open market.
- Average system size by watts: values are chosen as representative values for solar systems from each of the Tier values. They are intended to represent system sizes that typical members of each group would purchase.
- Average system life values represent expected operating life of Lighting Global products.

1.2.6.2 Current household energy usage:

Current Household Energy Usage (# Units/HH)				
Technology	**Tier 1**	**Tier 1.5**	**Tier 2**	**Tier 3**
Torch lights/Lanterns	1	2	3	
Mobile Phone Charging	1	1	2	
DC Radio	-	1	-	-
DC TV	-	-	1	-
Small Generator	-	-	-	1

- Numbers of units of torch lights/lanterns, cell phones, dc radio, dc TV and small generator represent the numbers of appliances that are demonstrated to be in use in typical households of each tier based on FGDs and multiple survey documents.

1.2.6.3 Current household energy costs

- Typical purchase and operation costs of HH off-grid appliances were based on FGDs, field energy surveys and reports.

1.3 Total Cash and Financed Market for Off-Grid Solar

1.3.1 Beginning with World Bank demographic and population data for Ghana, the number of off-grid households by income quintile was derived. For this, a percentage of off-grid households by quintile was assumed, as follows:

Quintile	% Off-Grid
Highest 20%	1%
Fourth 20%	2%
Third 20%	3%
Second 20%	4%
Lowest 20%	70%

It was assumed that there is a general correlation between income and access to electricity. The highest quintile has the highest percentage of population that are both urban and connected to the grid. Evidence indicates that the vast majority of households connected to the grid are from the top two quintiles Similarly, it was assumed that virtually all people in the bottom quintile are off-grid.

1.3.2 From this, average household energy expenditure was determined based on income, with the assumption that all households spend an average of 10% of their income on energy.

Average rural household expenditure on energy varies considerably. A study from Sierra Leone found that the "cost of lighting, on average, occupied between 10-15% of household incomes. Households using generators were found to spend a greater proportion of their income (upward of 20%) on lighting."[313] Other research has shown household energy spending between 6-12% for low income segments in sub-Saharan Africa.[314] For the purpose of this research, we have assumed that households can allocate 10% of their income on average to energy.

1.3.3 The monthly energy budget for each household per quintile was calculated by multiplying monthly Household income by the assumed 10% of Household income spent on energy. Monthly Household income per month was calculated by multiplying per capita income per month by the avg. # of persons/household. Per capita income per month for each quintile is calculated by dividing the Share of the country GDP for each quintile by the population of each quintile, which is one-fifth of the country population. The share of the country GDP for each quintile is based on World Bank, World Development Indicators demographic data.

1.3.4 A simple model was used to evaluate the market using the World Bank income quintile data and average energy expenditures as input data.

1.3.5 In determining the monthly energy expenditure related to each tier, the following assumptions were made with guidance from the FGDs output:

[313] Lai, K., Munro, P., Kebbay, M., and Thoronko, A., "Promoting Renewable Energy Services for Social Development in Sierra Leone: Baseline Data and Energy Sector Research, Final Report," European Union, (July 2015).
[314] 10% is an acceptable figure for lighting and cell phone charging costs for low income groups. See: https://www.brookings.edu/blog/africa-in-focus/2017/03/17/figures-of-the-week-benefits-of-off-grid-electricity-solutions/

- **Tier 0**: Assumed to be an absolute energy poor household, relying solely on kerosene and charcoal both for cooking and lighting.
- **Tier 1**: The household was assumed to have access to 1 torch light/lantern powered by dry cells, charging services for a phone charged on average 8 times a month.
- **Tier 1.5**: The household was assumed to have access to 1 torch light and 1 lantern each powered by dry cells, one regular cell phone charged on average 8 times a month, and a radio powered by dry cells (assume access to 2 low quality cells) replaced 4 times a month.
- **Tier 2**: The household was assumed to have access to 1 torch light and 2 lanterns each powered by dry cells, one regular cell phone charged on average 8 times a month, and one smart phone charged on average 16 times a month, a DC TV powered by lead acid battery recharged once per week.
- **Tier 3**: The household was assumed to have access to a generator powering a number of appliances but available only for 2-3 hours a day.
- **Annualized energy costs** for each of the systems = ([Capital system cost/average system life in years]+[Monthly operating cost*12])

1.3.6 The potential market size for each solar tier was then calculated by multiplying the number of off-grid households per quintile that will be willing to pay for each solar tier by the cost of each system (system cost is based on representative data from Ghana, as shown in 2.2.5).

1.3.7 In determining the number of off-grid households per quintile that will be willing to pay for each solar tier, the key assumption of the model is that each off-grid household purchases only one system and that they will opt for the highest solar system tier they can afford.

- For cash purchases, the assumption was that they will be willing to save (set aside) up to 3 months (number of months can be adjusted on the 'HH Assumptions' tab) of their monthly energy budget to purchase the system.
- For PAYG/financed, the assumption was that they will be willing if their monthly energy budget is less than or equal to the monthly PAYG payment AND if the PAYG upfront payment is less than or equal to 3 months of their monthly energy budget.

1.3.8 The interest rate for consumer finance was estimated to be 70% p.a., based on information available on the typical interest rate charged by Microfinance Institutions in Ghana.[315]

2023 and 2030 Household Demand Scenario: Assumptions

1. The GIS analysis[316] estimates that by 2023, 63.6% of the population will be grid connected, 24.4% will be connected by mini-grids while 12.0% of the population will be connected by off-grid stand-alone solutions. By 2030, the GIS analysis estimated that 88.7% of the population will be grid connected, 7.9% will be connected by mini-grids while only 3.4% of the will be connected by off-grid stand-alone solutions. Based on these dynamics in the demographic patterns, coupled with the existing government plans, the following assumptions regarding the off-grid population based on the quintiles were made:

   - In the 2023 scenario, it was assumed that as the grid gets extended and mini-grids are deployed (based on GIS data), the households in the quintiles with the highest income will be given

[315] See: http://citifmonline.com/2015/06/02/gcb-to-maintain-lending-rates/
See also: https://www.myjoyonline.com/business/2016/April-25th/ghana-ranks-second-among-highest-interest-rates-countries.php
[316] See **Annex 1** for GIS methodology.

priority due to their relatively higher power demand and ability to pay for power consumption. Hence, the highest four quintiles were assumed to have only 0.5%, 1%, 1.5%, and 2% off-grid households respectively, while the lowest quintile was assumed to have 55.2% off-grid households**.** These assumptions have been made such that the total number of off-grid households assumed is equal to the GIS data 2023 estimate.

- Similarly, in the 2030 scenario, it was assumed that the higher income quintiles will be prioritized for electrification, based on economic considerations, above the lower quintiles. Hence, the highest four quintiles were assumed to have only 0.1%, 0.2%, 0.3%, and 0.4% off-grid households respectively, while the lowest quintile was assumed to have 16.1% off-grid households. These assumptions have been made such that the total number of off-grid households assumed is equal to the GIS data 2030 estimate.

Quintile	% Off-Grid (2023)	% Off-Grid (2030)
Highest 20%	0.5%	0.1%
Fourth 20%	1.0%	0.2%
Third 20%	1.5%	0.3%
Second 20%	2.0%	0.4%
Lowest 20%	55.2%	16.1%

2. Inflation rates for Ghana: According to the IMF World Economic Outlook data, inflation in Ghana is estimated to be at 6% in 2023. It was assumed that the rate will remain the same through 2030. Based on this assumption, the expected prices of the current household energy technologies and the solar alternatives were estimated using an annual price escalation factor of 1.06.

3. Based on a 2.2% population growth rate from the World Bank[317] and the population density dataset used in the study, the estimated total population will be 32,746,871 in 2023 and 38,135,204 in 2030.

4. The least-cost electrification analysis found that the share of the population with access to electricity via the national grid and mini-grids will be 88.0% in 2023 and 96.6% in 2030

5. To estimate GDP, it was assumed that the current annual GDP growth rate of 8.5% will be maintained through 2023 and 2030:

Parameter	2023	2030
Population	32,746,871 (GIS estimate)	38,135,204 (GIS estimate)
GDP (constant 2010 USD)	$78,635,249,865	$139,195,577,897

6. According to the Lighting Global Off-Grid Solar Market Trends Report 2018,[318] the price of pico solar products is expected to fall to USD 10.60 in 2020 and USD 10.10 in 2022 down from USD 10.90 in 2016. Based on these 2020 and 2022 figures, the average annual decrease in prices from 2020 was estimated at 2.36%. It was assumed that the annual price decrease will be maintained at this rate through 2030 (annual cost reduction factor of 0.98)

7. According to the same report, the price of small SHS components is expected to fall to USD 60.40 in 2020 and USD 47.40 in 2022, down from USD 77.80 in 2016. Based on these 2020 and 2022 figures, the average annual decrease in prices from 2020 was estimated at 10.76%. It was assumed that the annual price decrease will be maintained at this level through 2030 (annual cost reduction factor of 0.89)

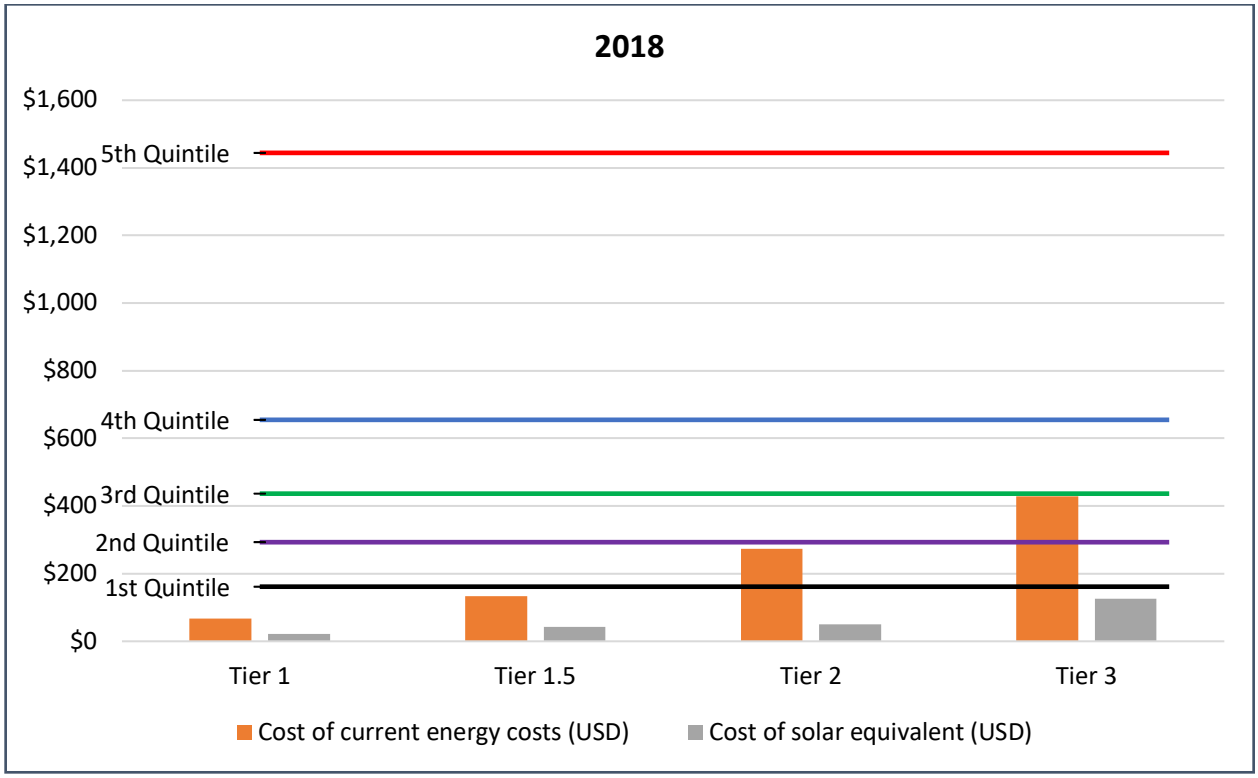
[317] https://data.worldbank.org/indicator/SP.POP.GROW?locations=BJ

[318] "Off-Grid Solar Market Trends Report 2018," Dahlberg Advisors, Lighting Global, GOGLA and World Bank ESMAP, (January 2018): https://www.lightingafrica.org/wp-content/uploads/2018/02/2018_Off_Grid_Solar_Market_Trends_Report_Full.pdf

8. It was assumed interest rates in Ghana will stagnate at the current rate of 70% or possibly decline.

Household Cost Savings and Affordability Calculation

Annual Household Energy Budget by Quintile, Annual Energy Costs and Annual Costs of Solar Equivalents



- This analysis presents annualized costs (not including financing cost) of current energy technologies for each energy tier, compared with the annual cost of an equivalent solar product. The same analysis was also completed for the 2023 and 2030 scenarios.

- Both the annual costs of current energy technologies and equivalent solar solutions considered the capital cost of each unit as well as the operating cost over the average lifetime of a unit.

- These costs were compared with a 10% monthly energy budget for households of different income quintiles. The analysis did not assess affordability for a cash vs. financed purchase over time.

2. INSTITUTIONAL DEMAND

2.1 Country Categorization

To assess institutional sector demand, the ROGEP countries were grouped into four categories based on income and population density, which are two key factors that influence the number of public service institutions in a given country. The countries were categorized as follows:

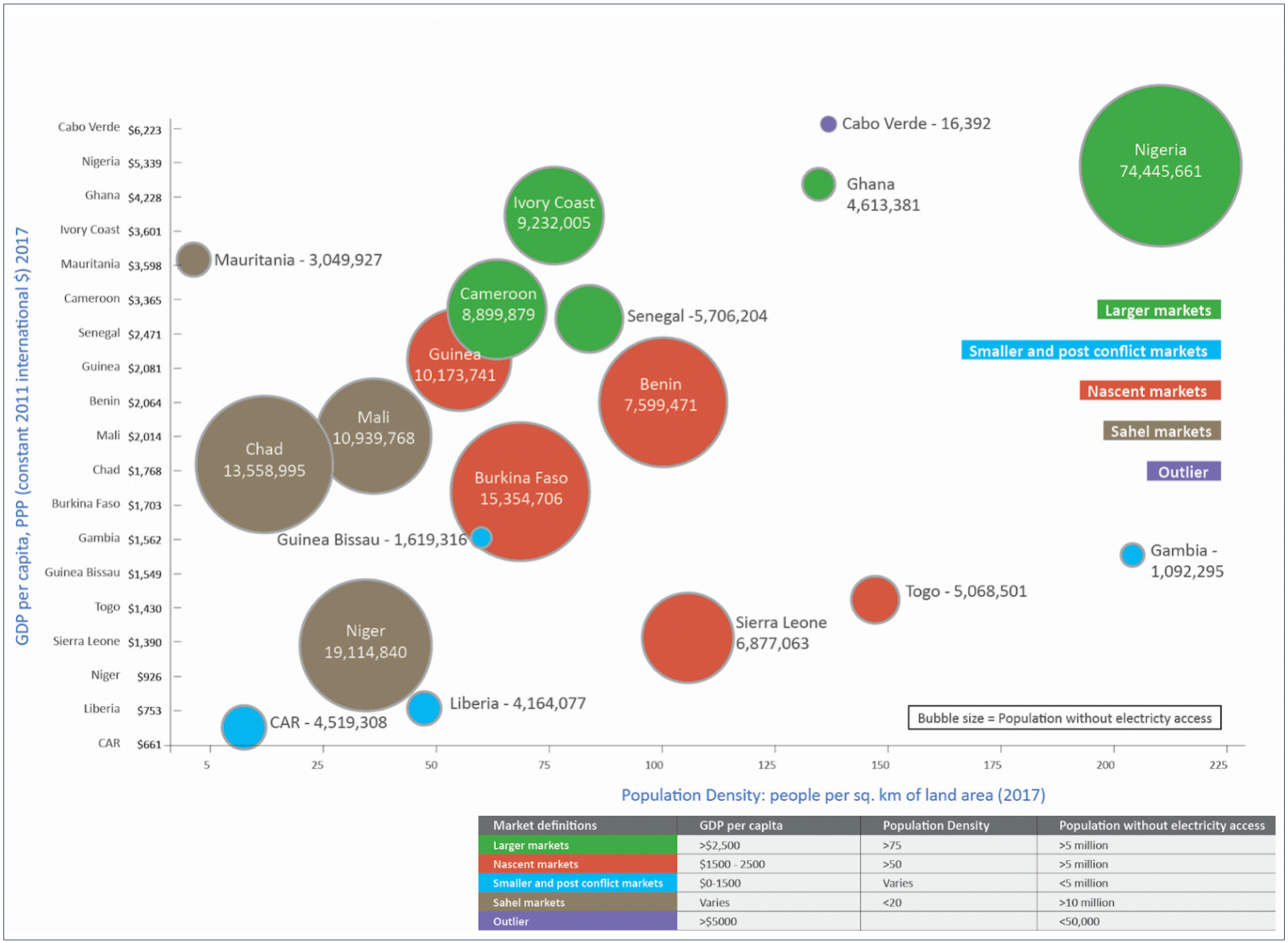
Country Categorization by Income and Population Density			
Category 1: Low-income / low population density	**Category 2:** Low-income / high population density	**Category 3:** High-income/ low population density	**Category 4:** High-income / high population density
Niger Burkina Faso Chad Mali Guinea Guinea-Bissau Central African Republic Liberia	Benin Sierra Leone Togo Gambia	Cameroon Côte d'Ivoire Mauritania Senegal	Nigeria Ghana Cabo Verde

These categories were used to address data gaps, as obtaining accurate and comprehensive data on the number of off-grid public institutions in many of the countries was challenging. Where data was not available, per capita assumptions based on data from similar countries in the same category were used. The following countries were used as reference countries for each category:

Category 1	Guinea, Liberia, Niger
Category 2	Benin, Sierra Leone
Category 3	Côte d'Ivoire
Category 4	Ghana

Categories are defined as follows (and illustrated in the figure below):

- Low population density: <95 people per square km of land area
- High population density: >95 people per square km of land area
- Low income: <$2,200 GDP per capita
- High income: >$2,200 GDP per capita



Market definitions	GDP per capita	Population Density	Population without electricity access
Larger markets	>$2,500	>75	>5 million
Nascent markets	$1500 - 2500	>50	>5 million
Smaller and post conflict markets	$0-1500	Varies	<5 million
Sahel markets	Varies	<20	>10 million
Outlier	>$5000		<50,000

Source: African Solar Designs analysis

2.2 Energy Needs by Institutional Market Segment

Institutional Sector	Description	Rating (W)	Time of use (hrs)	Total Wh/day	Total Load	Recommended system (W)
Water Pumping						
Low power		1,500	6	9,000		1,500
Medium power		4,000	6	24,000		4,000
High power		10,000	6	60,000		10,000
Healthcare						
HC1 Health post	Lighting	30	8	240		
	Communication	20	8	160		
	ICT	100	8	800	1,200	250
HC2 Basic healthcare facility	Lighting	200	8	1,600		
	Maternity	200	4	800		
	Vaccine refrigeration	100	8	800		
	Communication	100	4	400		
	Medical exams	200	2	400		
	ICT	200	8	1,600		
	Staff housing	50	8	400	6,000	1,500
HC3 Enhanced healthcare facility	Lighting	400	8	3,200		
	Communication	200	8	1,600		
	Medical exams	600	2	1,200		
	ICT	300	8	2,400		
	Maternity	600	4	2,400		
	Laboratory	1,000	2	2,000		
	Sterilization	1,200	1	1,200		
	Vaccine refrigeration	150	8	1,200		
	Staff housing	200	8	1,600	16,800	4,200
Education						
Primary school	Communication	20	8	160		
	Lighting	80	8	640		
	ICT	100	8	800		
	Staff house	50	8	400	2,000	500
Secondary school	Communication	20	8	160		
	Lighting	240	8	1,920		
	ICT	400	8	3,200		
	Laboratory use	100	8	800		
	Staff house	200	8	1,600	7,680	1,920
Public Lighting						
Street lighting	Lights	200	8	1,600	1,600	500

Source: The estimates in the table above are based on data obtained from local experts, interviews with solar industry stakeholders and corroborated by secondary desk research.

CALCULATIONS: Rating of systems is based on data for sizes of the appliances from a 2016 GIZ solar PV catalogue.[319] The solar PV sizing factor is based on the peak sun hours available across most of Africa.

[319] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf

Energy Needs Assumptions:

Water Supply: Power requirements (low, medium, high) are based on the type of water point:

- Borehole: 40% low power pumps; 40% medium power; 20% high power
- Protected dug well: 80% no pump; 10% low power pumps; 10% medium power; no high-power
- Unprotected dug well: No pump
- Protected spring: No pump
- Unprotected spring: No pump
- Public tap/standpipe (stand-alone or water kiosk): No pump
- Sand/Sub-surface dam (with well or standpipe): No pump
- Piped water into dwelling/plot/yard: No pump
- Rainwater harvesting: No pump

Healthcare: The size of the healthcare facility (HC1, HC2, HC3) determines the amount of energy each facility requires.

Education: The size of the school and number of students determines the amount of energy each school requires.

Public lighting: The electricity needs of a given town/market center (assuming two [2] public lighting points per market center)

2.3 Institutional Market Sizing Calculations

Household systems, cost and price per watt:

System Type	Tier Rating	USD/Watt[320]	Average Size (Watts)	Total Cost (USD)
Pico solar system	Tier 1	$15.00	3	$45.00
Basic Plug and Play system	Tier 1.5	$12.50	10	$125.00
Small HH solar system	Tier 2	$5.00	50	$250.00
Medium HH solar system	Tier 3	$2.50	250	$625.00

Size of systems used in institutional sector market sizing calculation:

Sector	Description	Size (corrected for time of use)	HH systems
Water Supply	Low Power	1,500	N/A
	Medium Power	4,000	N/A
	High power	10,000	N/A
Healthcare	HC1	250	Tier 3
	HC2	1,500	N/A
	HC3	4,200	N/A
Education	Primary	500	N/A
	Secondary	1,920	N/A
Public lighting		500	N/A

[320] Cost per watt derived from African Solar Designs analysis and from IRENA: https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets

Institutional Sector Market Sizing Calculations:

NOTE: Prices cover only solar components (except for the HC1 tier 3 system, which comes with lighting)

Water Supply						
# of water pumps	X	Size of solar system (watts) (low, medium, high power)	X	Cost per watt for pumping ($2.50) divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Water Supply Sector

Healthcare						
# of healthcare facilities	X		X		=	Estimated Annualized Off-Grid Solar Market Potential for Healthcare Sector
HC 1		Cost per tier 3 system ($625)		Divided by system lifetime of 5 years		
HC 2		Size of solar system in Watts (1500W)		Cost per watt ($2.50) divided by system lifetime of 20 years		
HC 3		Size of solar system in Watts (4200W)		Cost per watt ($2.50) divided by system lifetime of 20 years		

Education						
# of schools	X		X		=	Estimated Annualized Off-Grid Solar Market Potential for Education Sector
Primary		Size of solar system in Watts (500W)		Cost per watt ($3) divided by system lifetime of 20 years		
Secondary		Size of solar system in Watts (1920W)		Cost per watt ($2.50) divided by system lifetime of 20 years		

Public Lighting						
# of off-grid market centers	X	Size of solar system in Watts (500W)	X	Cost per watt ($3) divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Public Lighting Sector

2.4 Data Collection Approach by Institutional Market Segment

Ghana Institutional Market Analysis Methodology			
Water Supply	**Healthcare**	**Education**	**Public Lighting**
GIS data	GIS data	GIS data + stakeholder interviews	Per capita assumption

Data was collected on the total number of off-grid institutions by institutional market segment for Ghana from a combination of available GIS data, input from local experts, stakeholder interviews and desk research. Where there were gaps in available data, per capita assumptions were made, as explained in **Section 2.2**.

Assumptions:

Water Supply: Of the identified potable water points, it was assumed that 50% would be equipped with a solar-powered water pump. Of the equipped water sources, the division of pumps between low, medium

and high-powered pumps was: 50%, 35% and 15%, respectively. The lower cost of the low power pumps is the driving factor for this assumption. Where this information was not available, a per capita comparison was made with a country in the same category.

Available GIS data revealed 22,573 potable water points in the following six regions of the country: Brong Ahafo, Central, Northern, Upper East, Upper West and Western. Village water supply can be categorized into the following types of watering points, all of which have different energy supply needs:

- Hand dug wells
- Boreholes
- Mechanized boreholes
- Boreholes with fitted solar systems
- Hand dug wells with fitted pumps
- Spring water
- Water kiosk

From the GIS dataset,[321] only boreholes and the hand dug wells present statistically sound data that was used to assess the water supply market. To assess demand of the sector, GIS data was segmented into the various categories of water sources available. Since data on well depth, yields and how the population clusters around each of these water sources was not available, the water source was matched with appropriately sized motorized pumps (or no pumps if they are not viable pumping sites). These water sources and the corresponding type of water pump required for each type of water source are described in the table below.

Water Points and Type of Pump to be Installed

Water Source	Total Number of Water Points	Type of Pump Solutions
Springs	2	No pump to be installed.
Borehole	20,508	50% no pump installed 20% low power 20% medium power 10% high power
Hand dug well	1,942	50% no pump 25% low power pumps 20% medium power pumps 5% high power pumps.

Healthcare: Wherever possible, specific data on the number of off-grid healthcare facilities by size was used (i.e. HC1, HC2, HC3). Where this information was not available, a per capita comparison was made with a country in the same category.

Education: Wherever possible, specific data on the number of off-grid primary and secondary schools was used. Primary schools encompass both primary and nursery schools. Vocational schools and universities were not considered because they tend to be in cities, which are often grid-electrified. Where this information was not available, a per capita comparison was made with a country in the same category. The following per-capita assumptions were made:[322]

[321] World Vision water study, Ghana, (2017): https://www.worldvision.org/our-work/country-profiles/ghana

[322] Population without access to electricity:
https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
Population ages 0-14: https://data.worldbank.org/indicator/SP.POP.0014.TO
Population ages 15-19: https://data.worldbank.org/indicator/SP.POP.1519.MA.5Y;
https://data.worldbank.org/indicator/SP.POP.1519.FE.5Y

- **Primary school**: Per capita calculation using the off-grid population that is 0-14 years
- **Secondary school**: Per capita calculation using the off-grid population that is 15-19 years

Public lighting: Using population figures by region, and assuming that the population per market center was 5,000 people, the number of market centers was calculated. An assumption of two [2] public lighting points per market center was used in the calculation. No data on street lighting was included, as it was assumed that street lighting projects are linked to road infrastructure rather than institutions.

2.5 Ability to Pay Analysis (Strongest Potential Market Segment)

Data was not available to estimate the monthly energy expenditures of institutional users. Secondary data was available through government and donor program annual budgets for public services but was not comprehensive. A rudimentary analysis was undertaken based on these funding sources and compared to the total solar product market estimate for each institutional market segment in order to discuss the realistic potential market outlook based on the ability to pay. Due to a lack of data, the analysis was not able to take into account other potential sources of funding, such as funds pooled at the national or local level, fees for services etc.

3. PRODUCTIVE USE DEMAND

3.1 PUE Applications for Off-Grid Microenterprises (barbers and tailors)

The market sizing calculation for the barbers and tailors sector assumed that hair cutting and sewing appliances will be retrofitted to be powered by a Tier 3 DC solar system (5-year system life). By using a single price for all of the ROGEP countries, this methodology does not take into account country-specific cost and supply chain constraints.

Microenterprises					
# of financially constrained SMEs[323]	X	Cost per tier 3 system ($625)	Divided by system lifetime of 5 years	=	Estimated Annualized Off-Grid Solar Market Potential for SMEs

3.2 Value-Added PUE Applications

Available data from various sources such as the World Bank, the UN's Food and Agriculture Organization and GSMA was used to estimate the potential OGS market for productive use applications in each of the analyzed market segments – solar pumping for agricultural **irrigation**, solar powered **milling** and solar powered **refrigeration**.

3.2.1 Irrigation

The market sizing calculation for solar-powered irrigation was based on smallholder irrigation potential (i.e. the amount of irrigable land suitable for smallholder farmers) that could benefit from a solar pumping system ($650, 6-year system life, 120 W system). This methodology does not take into account affordability (ability to pay) nor does it account for country-specific cost and supply chain constraints.

[323] "MSME Finance Gap," SME Finance Forum: https://www.smefinanceforum.org/data-sites/msme-finance-gap

Value-Added PUE Applications – Solar Irrigation											
Irrigation Potential (hectare)[324]	X 25%	=	Smallholder Irrigation Potential (hectare)[325]	Divided by 0.3[326]	=	Estimated No. of Smallholder Farms Suitable for Solar Irrigation	X	$650 (cost of solar pumping kit)[327]	Divided by 6 year (life of system)	=	Estimated Annualized Off-Grid Solar Market Potential for irrigation

Methodology for identifying areas suitable for irrigation activities on farms:

The areas for potential irrigation activities were calculated using the visible cropland[328] adjacent to permanent surface water sources. As identified by experts in a study in Zambia[329] and based on other expert consultations, beyond a 5 km distance from surface water, the returns are not economically feasible. **Figure 38** is a map of the cropland within a 5 km distance from permanent surface water.

3.2.2 Milling

The market sizing calculation for solar-powered milling utilized a series of inputs from the UN Food and Agriculture Organization to estimate the smallholder milling potential that could benefit from a 6.5 kW solar powered milling system (20-year system life). Cereals (e.g. rice, maize, millet and sorghum) as well as roots and tuber crops (e.g. cassava, yams and potatoes) were analyzed, as they provide an opportunity for value addition through hulling or milling.

Value-Added PUE Applications – Solar Milling													
Cereals, roots tuber crops (tons)[330]	X	70%[331]	X	50%[332]	=	Smallholder Milling Potential (tons)	Divided by 2 tons per day X 70% capacity factor[333]	=	Estimated No. of Solar Mills	X	6,500 W x $2.50 per watt Divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Milling

Ultimately, the ability for an agricultural community to benefit from productive use applications has as much to do with access to markets and improved crop inputs, as it has to do with the pricing and availability of financing to purchase the equipment. Hence, the macroeconomic approach used to carry out this market sizing does not account for country-specific cost and supply chain constraints.

[324] AQUASTAT – Food and Agriculture Organization: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
[325] Assumption that 25% of irrigable land irrigated by smallholder farmers;
See: "Lessons Learned in the Development of Smallholder Private Irrigation for High Value Crops in West Africa," World Bank, (2011): http://siteresources.worldbank.org/INTARD/Resources/West_Africa_web_fc.pdf
[326] Assumption that smallholder private irrigation consists of small farms (0.3 hectare);
See: "Off-grid Solar Market Assessment in Niger and Design of Market-based Solutions," World Bank, (December 2017): https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/
[327] 120W solar pumping kit: https://futurepump.com/futures-bright-farmers-kenya/
[328] "Prototype Land Cover Map over Africa at 20m Released," Esa, (February 2018): https://www.esa-landcover-cci.org/?q=node/187
[329] "Zambia Electrification Geospatial Model," USAID and Power Africa, (April 2018): https://pdf.usaid.gov/pdf_docs/PA00T2JC.pdf
[330] Food and Agriculture Organization: http://www.fao.org/faostat/en/#data/RF
[331] Assumption that 70% of crops are milled
[332] Assumption that 50% of milled crops are processed at smallholder farmer level
[333] Solar mill (6.5 kW system) can mill 2 tons of produce per day; assume capacity factor of 70% (for maintenance/seasonality)
See: "Off-grid Solar Market Assessment in Niger and Design of Market-based Solutions," World Bank, (December 2017): https://www.lightingafrica.org/publication/off-grid-solar-market-assessment-niger-design-market-based-solutions/

3.2.3 Refrigeration

The market sizing calculation for solar-powered refrigeration utilized the estimated number of off-grid market centers in each country to estimate the number that could benefit from a 5.5 kW solar refrigeration system (20-year system life).

Value-Added PUE Applications – Solar Refrigeration							
# Off-Grid Market Centers by country[334]	X	5,500 W[335]	X	$2.50 per watt	Divided by system lifetime of 20 years	=	Estimated Annualized Off-Grid Solar Market Potential for Refrigeration

3.3 PUE Applications for Connectivity/Mobile Phone Charging Enterprises

The market sizing calculation for solar-powered phone charging enterprises was based on each country's mobile phone penetration rate (number of unique subscribers), rural population rate, and the average costs of OGS phone charging appliances ($862, 5-year system life, 400 W system).

Mobile Phone Charging Enterprises							
# of Mobile Phone Subscribers in 2017[336]	X	% rural population	Cost of solar phone charging appliances* divided by lifetime of 5 years	X	0.01 (assuming 1 phone charger per 100 mobile phone users)	=	Estimated Annualized Off-Grid Solar Market Potential for Phone Charging Enterprises

* Indicative Costs for Phone Charging Appliances[337]

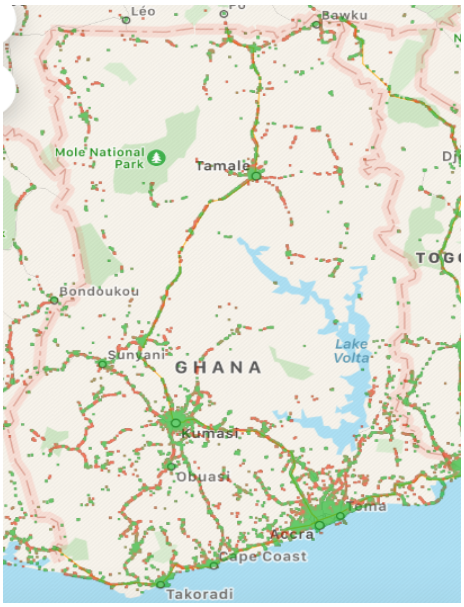
Charging Stations	Cost (USD)	Manufacturer
Charging ECOBOXX Qube (sizes - 50) 5Wp panel	$83	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Charging ECOBOXX Qube (sizes - 90) 10Wp panel	$205	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Charging ECOBOXX Qube (sizes - 160) 2*10Wp panel	$209	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station ECOBOXX 300	$681	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station ECOBOXX 600	$965	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable Charging Station ECOBOXX 1500	$1,532	EcoBoxx/ Sungrid Group (PTY) LTD South Africa
Portable charging station BOSS Kit Portable	$3,025	Phaesun GmbH
Charging Sundaya Charging Station	$193	Sundaya
Average Cost	**$862**	

Source: GIZ and African Solar Designs analysis

Identifying areas of phone network coverage

The mobile phone network geographic coverage was mapped across each country. The source for this data is GSMA, which gives a radius ranging between 2-30 km. The radius is affected by a number of variables including tower height, power output, frequencies in use, and antenna type. Since this does not indicate the quality of network, the data was compared with data from OpenSignal, which tracks the signal from users registered on the platform (**Figure 40).**

[334] https://www.citypopulation.de
[335] 5.5kW solar powered refrigeration system – *See*: https://www.deutschland.de/en/solar-powered-coldhubs-nigeria
[336] "The Mobile Economy, Sub-Saharan Africa," GSMA Intelligence, (2017): https://www.gsmaintelligence.com/research/?file=7bf3592e6d750144e58d9dcfac6adfab&download
[337] "Photovoltaics for Productive Use Applications: A Catalogue of DC-Appliances," GIZ, (2016): https://www.sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/GIZ__2016__Catalogue_PV_Appliances_for_Micro_Enterprises_low.pdf



Green: Strong Signal (>-85dBm)
Red: Weak Signal (<-99dBm)
Source: Open Data Signal

3. SUPPLY CHAIN ANALYSIS

The Task 2 supply chain analysis was based on the following key sources of data:

- Supplier focus group discussions held in Accra in June 2018
- Survey of 10 locally-based solar companies/suppliers in the country
- Survey of 10 larger international solar product suppliers
- ECREEE supplier database
- GOGLA semi-annual sales reports[338]
- Additional supplemental desk research and solar industry stakeholder interviews

These findings were subsequently corroborated by attendees of national validation workshops held in each country at the conclusion of the market assessment. A list of identified solar companies that are active in Ghana is included below:

1	Azuri Ghana
2	Barefoot Power
3	Burro Brands
4	DENG
5	Dutch & Co
6	ENGIE
7	Franerix
8	Greenlight Planet
9	Kwamoka Energy
10	Nocheski
11	NorthLite Solar
12	OGE
13	PAYGO
14	PEG Ghana
15	Power &Co
16	Smart Energies
17	Solar Light
18	Strategic Power Solutions
19	Süka Ghana
20	SunPower
21	Tradeworks
22	Villageboom
23	Umawa Solar
24	Wilkins Engineering
25	Yenso Solar
26	Yingli Solar
27	Zola Energy

Source: ECREEE, Focus Group Discussions; Stakeholder interviews

[338] "Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2018): https://www.gogla.org/sites/default/files/resource_docs/global_off-grid_solar_market_report_h1_2018-opt.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth2-2017_def20180424_web_opt.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2017): https://www.gogla.org/sites/default/files/resource_docs/gogla_sales-and-impact-reporth12017_def.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (July – December 2016): https://www.gogla.org/sites/default/files/recource_docs/final_sales-and-impact-report_h22016_full_public.pdf
"Global Off-Grid Solar Market Report: Semi-Annual Sales and Impact Data," GOGLA, Lighting Global and World Bank, (January – June 2016): https://www.gogla.org/sites/default/files/recource_docs/global_off-grid_solar_market_report_jan-june_2016_public.pdf

ANNEX 3: TASK 3 METHODOLOGY

FINANCIAL INSTITUTION ASSESSMENT

Data collection under Task 3 included a combination of desk research, collaboration with local experts, and extensive stakeholder engagement with key officials and representatives from local and regional commercial banks, microfinance institutions and other development banks and agencies in Ghana. Interviews were also conducted with regional development banks (namely BOAD and EBID) and other financiers active in the African off-grid solar sector, including export credit agencies, trade funders, crowd funders and impact investors.

The stakeholder engagement activity, which included both phone interviews as well as in-person meetings with key representatives from each FI, was undertaken across the 19 countries with extensive support from ECREEE. As a follow up to each interview/meeting, a questionnaire was administered in order to gather critical data on each institution, including *inter alia* their level of experience and capabilities with off-grid sector lending, SME and consumer lending, relationships with local and international partners etc. Feedback from the interviews and questionnaire, as well as quantitative data from each bank's published annual reports, was compiled and analyzed in order to assess which FIs could be most suitable local partners / implementing agents for the proposed ROGEP facility.[339]

The questionnaire that was administered to FIs in the country and across the ROGEP region is included below.[340] The results of the survey are summarized in **Section 3.4**.

- Has the bank provided any loans to any segment of the off-grid sector? If so, please describe.
- Has the bank received any inquiries from any segment of the off-grid sector? How many inquiries?
- Did the bank engage in serious discussions or dismiss the inquiry(ies) as not within the bank's area of lending or not interesting as a new business line? If dismissed, please provide the bank's reasons.
- If the bank engaged in serious review/discussions and rejected the opportunity, please describe the bank's due diligence approach and reasons for rejection.
- Is the bank interested to pursue lending to any segment of the off-grid sector? Which segment and which of the bank's departments and existing products apply?
- Describe the bank's current loan products and lending activity for the SME, Corporate, Consumer and Agri markets. Please provide rough figures on volumes in number of loans and value in each category. For each category please provide average margins, pricing, loan tenors to borrowers, collateral requirements.
- Does the bank have a structured finance department? Has the bank provided financing to any IPPs? If so, please provide details on the transactions (location, technology, size, maturity, portion of bank engagement in the total financing)
- Does the bank have a trade finance department? What are standard terms and conditions? What are the volumes in number of loans and values?
- Does the bank operate nationwide or only in certain regions? Does the bank have a presence in rural areas and is rural consumer and SME and Agri lending a key business focus?
- Does the bank have experience with managing DFI credit lines? In which sectors/departments? Which DFIs? What volumes? Were the lines fully committed and disbursed? What was the bank's overall experience with these credit lines?
- Has the bank had dealings with the ECOWAS Bank for Investment and Development (EBID)? What type of relationship? Credit lines? Co-lending? Credit enhancement? Have the experiences been positive?
- What is the bank's view on accepting hard currency credit lines and on-lending in hard currency? Would the bank hedge hard currency credit lines and on-lend in local currency?

[339] The results of this assessment and corresponding recommendations were prepared for ECREEE in a separate, confidential report.
[340] The survey was adapted based on the type of FI that was being interviewed (commercial banks, MFIs, Regional Development Banks)

- Is the bank interested to explore a credit line with ROGEP? What size of credit line would the bank be comfortable launching with initially?
- Does the bank feel that it would need a third-party guarantee in order to reduce risk enough to make loans to off-grid enterprises? If so, would it be enough if a guarantor were to cover 50% of losses on par with the bank? Or will the bank need the guarantor to take the first 10-20% of losses in an off-gird loan portfolio?
- What pricing does the bank consider to be fair and affordable for third party pari-passu guarantees? For first loss coverage?
- Has the bank had experience with any of the following as guarantors on the bank's loans: Africa Guarantee Fund, Africa Trade Insurers, Afrexim Bank, GuarantCo, IFC, USAID DCA? Has their pricing been fair and affordable? Does the bank have any preference in working with one over the others?
- To engage in lending to the off-grid market segments, would Technical Assistance be helpful? What types of TA would be most useful? Outside consultants to help design specific loan products and underwriting guidelines for the off-grid sector? Outside consultants to develop deal flow and conduct due diligence? Training of bank credit department and account representative personnel? Direct funding to the bank to develop marketing and promotional materials and hire staff?
- Does the bank adhere to and is in compliance with all aspects of the Basel II and III accords?
- Does the bank adhere to and have implemented controls for the Equator Principals and the World Bank/IFC Environmental and Social Standards?

ANNEX 4: GENDER ASSESSMENT

1. Context and Purpose of the Gender Analysis

Within the context of this assignment, a gender-focused analysis was undertaken to assess the level of participation of women in each country's off-grid energy sector. This analysis is critical to the overall market assessment given the clear linkages between energy and gender, namely different rates of access and use as well as the impacts of energy sources and appliances in the home, community and wider society. Energy sector studies often fail to obtain gender-disaggregated data, which is necessary to inform policymakers and better understand the needs and priorities of women in the context of sustainable development.

Women in energy-poor households are at substantially higher risk of illness attributable to indoor air pollution and solid fuel (biomass) use.[341] Moreover, the significant time burdens that women and girls face in collecting fuel and water, cooking and processing food often keep girls from attending school; there is evidence that electrified milling equipment and water pumps can significantly reduce this burden. Lack of access to electricity also means that women do not have access to information and communication technologies that could improve their lives.[342]

As a region, West Africa and the Sahel has remained traditionally gender-stratified whereby males on average have greater access to resources, are more empowered by society and have more opportunities than women.[343] To address these challenges, governments across the region have adopted a range of policies to improve gender equality and promote gender mainstreaming. Member states of ECOWAS have adopted a Policy for Gender Mainstreaming in Energy Access, an initiative committed to promoting favorable policies and frameworks and mobilizing resources to more fully engage women in all areas of energy access, including as energy suppliers, planners, financiers, educators and customers.[344] ECREEE, the agency that is administering this policy throughout the region, is supporting implementation of regulatory and institutional measures that aim to improve inclusive energy access in each country by 2030. ECREEE has also partnered with AfDB to launch a separate regional initiative to advance the participation of women entrepreneurs in the renewable energy sector.[345]

Outside of ECOWAS, Cameroon, Chad and Central African Republic are pursuing gender mainstreaming at a regional level through the Economic Community of Central African States (ECCAS) Regional Policy for universal access to modern energy services and economic and social development (2014-2030).[346] Mauritania is also implementing a national policy to address this issue – the National Strategy of Institutionalization of Gender (la Stratégie Nationale d'institutionalisation du genre).

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[341] "The Energy Access Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa," UNDP and World Health Organization, (2009): http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/Sustainable%20Energy/energy-access-situation-in-developing-countries.pdf

[342] Rewald, R., "Energy and Women and Girls: Analyzing the needs, uses, and impacts of energy on women and girls in the developing world," Oxfam, (2017): https://www.oxfamamerica.org/static/media/files/energy-women-girls.pdf

[343] "Situation Analysis of Energy and Gender Issues in ECOWAS Member States," ECREEE, National Energy Laboratory, (2015): https://www.seforall.org/sites/default/files/Situation-Analysis-of-Energy-and-Gender-Issues.pdf

[344] Ibid.

[345] "Feasibility study promotes women's participation in energy transition," ESI Africa, (May 7, 2018): https://www.esi-africa.com/feasibility-study-promotes-womens-participation-in-energy-transition/

[346] "Central Africa Regional Integration Strategy Paper," African Development Bank, (2011-2015): https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/RISP%20CENTRAL%20AFRICA-ECCAS%20English%20FINAL.pdf

➢ Description of Approach / Methodology

While the data collection for this assignment was not sex dis-aggregated (which was beyond the scope of work), a gender-focused perspective was applied to the overall analysis. The methodology adopted to carry out this exercise included a combination of desk research, literature review, focus group discussions (FGDs) and face-to-face interviews with key gender "focal points" identified by ECREEE in each country. Representatives from women's groups, female-led businesses and energy sector organizations attended the focus group meetings that were held in Accra in June 2018 to share their insights and inform the overall market study. A gender questionnaire was also distributed to key stakeholders in Ghana to assess the main barriers/constraints for inclusive participation in the country. The survey examined a number of key gender issues, including *inter alia* access to credit, access to education and information, entrepreneurial and income-generating activities for women (including productive use of energy), representation of women in leadership positions in business and government.

➢ Gender Questionnaire

The following questionnaire was administered to key stakeholders in each country. Respondents were asked to reply Yes/No to each question and elaborate as needed.

HOUSEHOLD

Are women generally involved in influencing decisions on household energy use/services?
Are off-grid solar solutions (E.g. solar lanterns, solar home systems) largely accessible/made available to the household sector, particularly women-headed households?
Are there any related programs and initiatives (donor, government, private sector, NGO etc.) that are specifically targeting energy access for women in the household sector?
Are off-grid solar products and services generally affordable for households headed by women? If not, are Microfinance Institutions or other organizations in the country providing credit/financing (grants/loans) to the household sector, particularly women-headed households to increase energy access?
Are women aware of the health impact of unclean energy (e.g. fuel-wood for cookstoves) and the solutions (i.e. solar) to address it?

COMMUNITY/INSTITUTIONAL

Are women represented in any high-level energy sector positions? Please provide names/examples, if available, of women in senior management positions in government, committees, boards etc.
Is the mobility and safety of women constrained due to poor energy services (e.g., unavailability of streetlights due to unreliable electricity supply)?

PRODUCTIVE USE

What kind of productive use activities do women engage in and what women-led productive use activities can be supported by off-grid solar solutions?

- Agriculture (irrigation, water pumping etc.)
- Shops (retail, artisanal/handicrafts, grocery, salons etc.)
- Restaurants (bar, cafe etc.)
- Kiosks (e.g. mobile money etc.)
- Tourism
- Other

SUPPLIER

Please describe the level of engagement that women have in in the off-grid energy services sector. Are women highly employed in this area (e.g. is there data collected on the number of women-owned businesses/SMEs)?

Are there any related programs and initiatives (donor, government, private sector, NGO etc.) that provide training for women to manage or be employed by energy-related enterprises?

ADDITIONAL:
What are the main barriers women face to access information?
What are the main barriers/constraints for women entrepreneurs to have access to credit?
Do women have equal access to capacity building and training services (e.g. vocational training/technical education) or do they experience discrimination in access to these services?
What policy, regulatory and institutional framework(s) exist, if any, to address gender mainstreaming[347] (e.g. national gender action plans/related policies etc.)?
Are gender-related issues taken into consideration in energy policy provisions and/or are energy-related issues reflected in gender policies (e.g. existence of 'gender units' within public sector agencies and/or 'gender audits' in energy sector)?

2. Gender Profile

2.1 The state of gender equality in Ghana

Structural inequalities and gender discrimination against women and girls persist in Ghana, as inclusive participation remains an ongoing challenge. While there have been improvements in recent years to certain social indicators such as education as well as healthcare, gender disparities still exist across the economy, particularly in access to resources, political power and decision-making. These findings are largely supported by UNDP Human Development Index (HDI) rankings. Ghana's HDI value for 2017 places the country in the medium human development category, which is higher than most of the other countries in Sub-Sharan Africa, but still below average globally.[348]

2.2 Gender and poverty

According to the UN, Ghana's national levels of poverty and extreme poverty have decreased significantly over the last 20 years, declining by more than half (from 56.5% to 24.2%).[349] Despite this trend, inequality has been increasing and poverty remains prevalent, particularly in rural areas.[350] An estimated 25.7 % of the labor force is still considered working poor at PPP $3.10/day.[351]

2.3 Gender, Human Capital and Economic Empowerment

2.3.1 Education, Skills Development and Training

While the Ghana has made considerable progress, the education sector still faces several challenges, including high drop-out rates and uneven degrees of access to education. Following the most recent round of elections, however, the Government has started implementing several key reforms to the education sector, including free secondary education for the population. In the area of higher education, rates of

[347] **Gender mainstreaming**: The process of ensuring that women and men have equal access to and control over resources, development benefits and decision-making, at all stages of development process, projects, programs or policy.
[348] "Human Development Indices and Indicators: 2018 Statistical Update," UN Development Programme, (2018): http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
[349] The Ghana Poverty and Inequality Report, UNICEF, (2016).
[350] Ibid.
[351] UN Human Development Indicators: Ghana," UN Development Programme, (2018): http://hdr.undp.org/en/countries/profiles/GHA

enrollment in Sub-Saharan Africa are among the lowest in the world. In West Africa and the Sahel region, Ghana ranks second behind only Cabo Verde, with a national enrollment rate of 12 %.[352]

Female access to higher levels of education in the country remains lower compared to men (**Figure 9**). While overall adult literacy rates are high (71.5%), only 51.8% of adult women have attained at least a secondary level of education compared to 68.5% of their male counterparts.[353]

Varying formal and informal Technical and Vocational Education and Training (TVET) programs are offered at institutions across the country. The percentage of females pursuing non-traditional technical skills programs (e.g. electronics, masonry, carpentry, plumbing, auto-mechanic) in Technical and Vocational schools accounts for less than 15% of total enrollment.

The GoG is in the process of finalizing the new Education Strategic Plan (ESP) 2018-2030, guided by the Government's desire to create an inclusive education system through improved access and equity, and provision of quality and relevant educational opportunities for all. The ultimate goal of the plan is to ensure that education plays a critical and positive role in the national development agenda and in helping to integrate international development goals into this agenda.[354]

2.3.2 Fertility Rates and Reproductive Health

Ghana has a universal healthcare system strictly designated for Ghanaian nationals – the National Health Insurance Scheme (NHIS). Access to health services varies by region, with urban areas typically better served than rural areas. As of 2017, the fertility rate in Ghana remained high, at 4.2 children per woman. Ghana's maternal mortality rate is among the highest in the world; for every 100,000 live births, 319 women die from pregnancy-related complications. The infant mortality rate also remains extremely high at 41.2 per 1,000 births. As of 2018, 26,3% of women had an unmet need for family planning.[355]

2.3.3 Participation and Decision-Making

Socio-cultural perspectives in Ghana remain male-dominated, as conventional gender roles continue to hold women back. Female participation in the labor market is 74.8% compared to 79.2% for men.[356] Ghana has implemented quotas in its party platforms for women to create a critical mass of women leaders and empower women to have a substantial impact in public life. Voluntary quotas are usually adopted by political parties on a voluntary basis. The existing electoral system is First Past the Post (FPTP) in Ghana. Despite a gradual increase in representation of women in the legislature and at the local government level, female political participation remains low – as of 2017, women hold only 12.7 % of the country's seats in parliament.[357]

[352] Situation analysis of Energy and Gender in ECOWAS, SE4All, 2015, https://www.seforall.org/sites/default/files/Situation-Analysis-of-Energy-and-Gender-Issues.pdf
[353] "Human Development Indices and Indicators: 2018 Statistical Update," UN Development Programme, (2018): http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
[354] "Indicators on Gender, Poverty the Environment and Progress toward the Sustainable Development Goals in African Countries," African Development Bank, (2017): https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/GENDER_Poverty_and_Environmental_Indicators_on_African_Countries-2017.pdf
[355] "Human Development Indices and Indicators: 2018 Statistical Update," UN Development Programme, (2018): http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
[356] Ibid.
[357] Ibid.

2.4 Gender Policy, Institutional and Legal Framework in Ghana

2.4.1 Gender Mainstreaming initiatives by the Government

Gender equality gained widespread support in post-war Ghana's development planning and discourse with the development of the Women's Manifesto starting in 2003 and Analysis on Children and Women in Ghana (2011). As a result, the Government of Ghana has adopted gender mainstreaming as a policy measure to improve gender equality and address poverty reduction, economic growth, and sustainable development.

The country's 1992 constitution guarantees gender equality and freedom of discrimination on the basis of social or economic status. The Government has enacted a number of laws to ensure the protection and promotion of the rights of women and children and to create an enabling environment to ensure inclusive participation in the country's development including the Human Trafficking Act (2005) and Children's Act (1998). The Ministry of Gender, children and social protection of Ghana is the government ministry responsible for the formulation of policies that promote the institutionalization and development of women and children issues.

Ghana's policy framework for promoting gender equality and women's empowerment is guided mainly by the Women's Manifesto starting (2003) and Analysis on Children and Women in Ghana (2011) and reinforced by the National Gender and Children's Policy adopted in 2004. The National Gender Policy (NGP) focuses on mainstreaming gender equality, women empowerment and social protection. Gender mainstreaming initiatives set by the Government are project specific interventions such as promotion of girls' enrollment into Technical and Vocational training institutions to pursue non-traditional careers through provision of scholarships for girls from poor households.

In the energy sector, the Ministry of Energy has undertaken gender audits and have developed Gender Action Plans (GAPs) even though in implementation. In the off-grid sector, the most notable gender-based work is Ghana's SREP (Scaling Up Renewable Energy Program in Low Income Countries) investment plan towards a gender-sensitive institution. These include the hiring of a gender expert at the Renewable and Alternative Energy Directorate, as well as women targeted consultations and communications, and use of participatory feedback mechanisms. The investment plan also includes a gender-sensitive vision, clarifying that among its outcomes that it seeks "more gender-equitable access to modern energy services and to employment opportunities in renewable energy enterprises." Finally, proper health, safety and environmental standards were put into place under the plan.

Other programs and or initiatives include (but are not limited to):

- Women's group own and operate hundreds of Multifunction Platforms (MFPs) across five West African countries (Ghana) with assistance from UNDP
- The Gyapa stove project
- Women's group own and operate hundreds of Multifunction Platforms (MFPS)/UNDP
- Women and Solar Entrepreneurship Program
- ECOWAS Policy for Gender Mainstreaming in Energy Access

2.4.2 Gaps in the Gender Policy/Legal Framework

Despite the Government's policy initiatives and legislative reforms, gender inequality remains an ongoing challenge across Ghana's political, economic and socio-cultural landscape, as women still face many barriers to inclusive participation. Women are often curtailed in their access to information and decision-making. Moreover, Ghana has a plural legal system consisting of a mixed system of English common law

and customary law, statutory, customary, and religious laws, which creates contradictions and inconsistencies particularly in the areas of marriage and family laws and inheritance and property rights. Ghana's legal systems includes its Constitution and mixed system of English common law and customary law leading to contradictions and inconsistencies among the three.

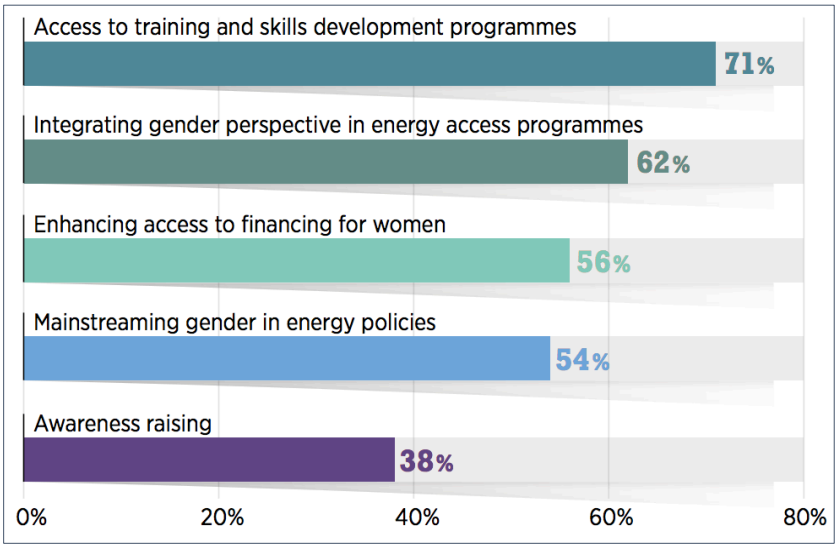
As described above, significant gender gaps persist in the areas of education, literacy, access to information and decision-making. There is also still a lack of sex-disaggregated data across all sectors of the economy, which is critical to inform policy decision and promote gender mainstreaming on a national scale.

2.5 Summary of Recommendations

Given the increased attention that gender inclusion has received in development planning, there are a number of tools that are now available to policymakers that can be utilized to support gender mainstreaming and encourage women's participation in the energy sector. Despite encouraging progress in the discourse on gender and energy access, substantial efforts are still needed, especially in enabling women's participation in the sector in different roles, including as energy entrepreneurs and in leadership positions.[358]

In seeking solutions to improve women's engagement in energy access, a 2018 IRENA survey found that access to necessary technical, business or leadership skills development programs was the single most important measure that could be taken. Over half of survey respondents also highlighted the need to integrate gender perspectives in energy access programs as well as enhanced access to finance.[359]

Measures to Improve Women's Engagement in Energy Access



Source: International Renewable Energy Agency

[358] "Renewable Energy: A Gender Perspective," International Renewable Energy Agency, (2019): https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Gender_perspective_2019.pdf
[359] Ibid.

In addition to the measures highlighted in the figure above, below is a list of additional policy recommendations that could further improve gender equality in Ghana's energy sector:[360]

- Take measures to close the gender gap in access to education, particularly in higher levels of education
- Implement a quota system to increase the number of women employed in government's energy ministry and ensure that women are part of decision-making processes in the energy sector
- Implement policy and budgetary measures to support programs that aim to raise awareness and promote opportunities for women as energy customers, suppliers, financiers, and educators
- Commission studies to collect, synthesize and publish gender-specific/sex-disaggregated data on women's energy access and usage to inform (i) public policy development to improve rates of access for women; and (ii) private sector on potential customer needs (e.g. clean cooking technologies, productive use of energy applications etc.)
- Undertake a "gender audit" of the energy sector and develop a gender action plan to inform long-term policy objectives targeting gaps in the existing framework and promoting inclusive participation (e.g. by adding gender categories to policies and accounting for gender impacts in strategic planning).
- Establish a Gender Focal Point or Unit within key national and local institutions in order to administer targeted gender policies and programs
- Raise awareness / provide training and technical support to private sector businesses / SMEs on (i) the benefits of gender inclusion and in viewing business decisions through a gender lens; (ii) the value of gender-disaggregated data; and (iii) how to develop and implement gender strategies to encourage inclusive participation.[361]

[360] NOTE: This is not an exhaustive list of recommendations as it is only intended to address inclusive participation in the energy sector; there are many gender-related challenges that warrant further study and attention within the context of the country's complex economic and social structures that are beyond the scope of this analysis

[361] "ECOWAS-CTCN Project on Mainstreaming Gender for a Climate Resilient Energy System in ECOWAS Countries: Final Report," ECREEE and CTCN, (May 2018): https://www.ctc-n.org/system/files/dossier/3b/180627_final_report-uk.pdf

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